DOCUMENT RESUME

ED 259 172 CE 041 890

AUTHOR	Sloan, Kelly; Hilley, Robert
TITLE	CNC Turning Technician. A Competency-Based Instructional System.
INSTITUTION	Oklahoma State Board of Vocational and Technical Education, Stillwater. Curriculum and Instructional Materials Center.
PUB DATE	84
NOTE	371p.; Developed jointly with Baxter Technologies, Inc. Photographs will not reproduce clearly.
AVAILABLE FROM	Curriculum and Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, OK 74074 (in-state: $6.00; out-of-state: $35.00).
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Behavioral Objectives; Classroom Techniques; *Competency Based Education; *Job Skills; Learning Activities; Learning Modules; *Machine Tool Operators; *Machine Tools; *Numerical Control; Secondary Education; State Curriculum Guides; Teaching Methods; Units of Study; Vocational Education
IDENTIFIERS	Computer Assisted Manufacturing; Computerized Techniques; Lathes; Oklahoma

ABSTRACT

This competency-based curriculum guide for instructing students in using computer numerically controlled (CNC) turning machines is one of a series of instructional guides for the machinist field developed in Oklahoma. Although developed jointly with Baxter Technologies Corporation and oriented toward the Baxter Vo-Tec 2000 Future Builder CNC Lathe, the principles covered and learning experiences provided are readily transferable to other available machines. This curriculum guide contains six instructional units. Each unit is based on a standard format that includes eight basic components: performance objectives, instructional overviews for the instructor, information sheets, assignment sheets, job sheets, instructor supplements, tests, and answers to tests and assignment sheets. Depending on the specific objectives, there may or may not be instructor supplements, assignment sheets, and job sheets included in the unit of instruction. All of the unit components focus on measurable and observable learning outcomes. Units of instruction are designed for use in more than one lesson or class period. Units cover the following operations: perform preventive maintenance, power up the machine and control, set up machine and test run program, evaluate first run, perform production run, and write a program. A glossary of codes and abbreviations is included in the package. (KC)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

BEST COPY AVAILABLE

OK 8413304

ED259172

CNC Turning Technician

A Competency-Based Instructional System

Written by

Kelly Sloan, CNC Production Instructor
Francis Tuttle Area Vocational-Technical Center

and

Robert Hilley, Development Specialist
Curriculum and Instructional Materials Center
Oklahoma State Department of Vocational and Technical Education
Stillwater, Oklahoma

Developed as a Cooperative Project by
Baxter Technologies Incorporated
John Thompson, Chairman

and

Oklahoma State Board of Vocational and Technical Education
John Folks, Chairman
Francis T. Tuttle, Director
Bob Patton, Coordinator,
Curriculum and Instructional Materials Center

CE 041890

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.

- Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

W Frazie

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

TI 1099

Copyright 1984
Baxter Technologies Corporation
and
State Department of Vocational and Technical Education
Curriculum and Instructional Materials Center

All rights reserved.

Printed in the United States of America by the
State Department of Vocational and Technical Education
Stillwater, Oklahoma 74074

This publication, or parts thereof, may not be reproduced in any form by photographic, electrostatic, mechanical, or any other method, for any use including information storage and retrieval, without written permission from the publisher.

Use of commercial products in these instructional materials does not imply endorsement by the Oklahoma State Department of Vocational and Technical Education.

The Oklahoma State Department of Vocational and Technical Education does not discriminate on the basis of race, creed, color, national origin, sex, age, veteran status, or qualified handicap.

CNC TURNING TECHNICIAN

TABLE OF CONTENTS

Unit I Perform Preventive Maintenance 1
Unit II Power Up Machine and Control 65
Unit III Set Up Machine and Test Run Program 115
Unit IV Evaluate First Run 215
Unit V Perform Production Run 287
Unit VI Write a Program 317
Glossary of Codes and Abbreviations 409

4

FOREWORD

Vocational educators in Oklahoma have a strong belief that quality vocational programs require the use of sound instructional materials. For that reason, the State Department of Vocational Education began developing educational products in 1970. Today, the Department's Curriculum and Instructional Materials Center is recognized internationally for producing quality competency-based vocational training materials.

In 1980, we began development of a series of instructor guides for the machinist field. These include *Machine Shop I, Machine Shop: Lathes, Machine Shop: Milling Machines,* and *Machine Shop: Grinding Machines.* As part of our goal to provide an instructional system to our users, we also developed slide/tape programs, learning activity packets, and a competency profile to supplement the texts. The development plan for the machine shop materials called for additional products to cover technological advances, with emphasis on computerized numerical control. We are pleased to introduce this volume, *CNC Turning Technician,* as the first such product along with the videotape programs and competency profile that accompany it.

Industry representatives, educators, and technical specialists from across the United States and Canada collaborated closely to produce these materials in the hope that students will gain the knowledge and skills required of the CNC turning technician through practical learning experiences. Coupled with the instructor's own methods and expertise, these materials should prove to be a valuable asset for CNC turning programs involving a diverse group of students, including advanced secondary students, post-secondary students, and adult students with various backgrounds in machining. The material is easily adaptable to open-entry/open-exit programs or other individualized formats, and the skilled instructor will be able to supplement, personalize, localize, and reorganize this material to meet specific training needs and local vocational requirements. The Instructional Overview with each unit and the "Use of This Publication" section provide valuable suggestions for developing a program around these materials. Although developed jointly with Baxter Technologies Corporation and oriented toward the Baxter Vo-Tec 2000 Future Builder CNC Lathe, the principles covered and learning experiences provided are readily transferrable to other available machines.

It is our sincere wish that *CNC Turning Technician* and the other manuals in this series will contribute to the development of a competent, safety-conscious work force in the machinist trade.

Francis Tuttle, Director
Oklahoma State Department of
Vocational and Technical Education

Bob Patton, Coordinator
Curriculum and Instructional
Materials Center

PREFACE

We must put down our old industrial tasks and take up the tasks of the future. — John Naisbitt in *Megatrend*

America must improve its productivity if it is to regain the standard of living it once enjoyed. Our growing trade deficit is a testament to the groaning productivity of America's industrial base. Not only must America revitalize its factories with computer controlled equipment, it must adopt new work methods and organizational structures to accommodate this new industrial revolution.

The task for you as educators is staggering. A whole generation of workers has to be trained or retrained in these new approaches, and this training can only be done with the full cooperation of industry, education, and government.

The *CNC Turning Technician* curriculum materials serve as an outstanding example of such cooperation. It has brought together Baxter Technologies' fifteen years of industrial experience with turning systems and the curriculum expertise of the Oklahoma State Department of Vocational and Technical Education under the guidance of a board of advisors representing educators and industrial users from across the country. The scope and content of this program testify to the fact that this linkage has worked.

There are 2,500,000 machine tools in use in America, of which 40 percent are turning systems. Currently, fewer than 150,000 are computer controlled. As industry invests in new technologies, the task to train and retrain America in the 1980s is going to be one of the major challenges facing you as educators.

We feel that this curriculum will greatly assist you in training the technicians needed for America's future.

John Thompson, Chairman and President
Baxter Technologies Corporation

6

ACKNOWLEDGEMENTS

The development of any set of instructional materials requires the contributions of many individuals if the materials are to meet the needs of instructors and students. This is especially true of *CNC Turning Technician* because we were writing in an area with very few educational resources. Exploring such uncharted territory can be done effectively only by relying on the knowledge, experience, and suggestions of a number of people. We were fortunate to have the enthusiastic support of many fine people during the development of the written instructional guide, the videotape programs, and the support materials that form the CNC turning technician instructional package. These individuals recommended the structure and content of materials and assisted with the implementation of the project. Our sincere thanks to

Warren Carmen
Machine Tool Technology Instructor
Sussex County Vocational-Technical School
Sparta, New Jersey

Mike Fitzpatrick
Precision/CNC Machining Instructor and
President, Washington Association of
Trade and Industrial Educators
Sno-Isle Vocational Technical Skills Center
Everett, Washington

Harley Gillett
Professor of Numerical Control Technology
Macomb Community College
Warren, Michigan

Jim Hannemann
Director of Industrial Education
Oakland Schools
Pontiac, Michigan

Raymond Harry
Vocational Education Program Coordinator
Washington State Board for Community
College Education
Olympia, Washington

Joyce Keefer
Curriculum Specialist
Ohio State University
Columbus, Ohio

Robert S. Patterson
Director, Texas Education Agency
Vocational Industrial Education
Austin, Texas

Robert T. Petroff
President, Amtech Industries
Lombard, Illinois

Ward Sievenpiper
Metalworking Institute of
Western New York
Buffalo, New York.

During the writing of these materials, we received invaluable support from our respective organizations. We wish to acknowledge the help provided by the faculty and staff of Francis Tuttle Area Vocational-Technical Education Center and express special gratitude to

Bruce Gray, Superintendent
Ralph E. (Gene) Callahan, Deputy Superintendent
Jim Wilson, Assistant Superintendent for High Technology.

The staff of the Curriculum and Instructional Materials Center of the Oklahoma State Department of Vocational and Technical Education also contributed substantial support and encouragement during the writing process. Our special thanks to

Francis Tuttle, State Director
Bob Patton, Curriculum and Instructional Materials Center Coordinator
Joyce Sawatzky, Curriculum and Instructional Materials Center Assistant Coordinator for Development.

Once the first draft was completed, several members of the curriculum committee met to review it and the videotapes. This meeting produced many significant suggestions for improving the presentation of the materials and for ensuring its accuracy and thoroughness. We are sincerely grateful for the diligent contributions of those who attended the two review meetings, including Warren Carmen, Mike Fitzpatrick, Harley Gillett, Jim Hannemann, and Ray Harry.

Throughout the development process we received unconditional support from Baxter Technologies Corporation. We are especially grateful to John Thompson, President, whose insight and faith in the project made our work possible. Our primary contact and advisor with Baxter Technologies was Andy Maharaj, CNC Application and Service Manager. Andy's untiring dedication and genuine concern for quality, as well as his willingness to help in all possible ways, served to clearly define the scope of the materials and patiently guide the project to completion. Additionally, Laurie Ball-Moss, CNC Applications, contributed a great deal of time and thought to content of the materials, and we would not have been able to have adequately covered the subject—especially the programming aspects of the CNC turning—without her able assistance and expertise. Special thanks are also extended to Lorraine Hemond who was in charge of product introduction for the Baxter Vo-Tec 2000 Future Builder CNC Lathe and the instructional package which accompanies it.

A number of people also contributed to the production phase of development in this project. Editing was handled by the CIMC editorial staff under the supervision of Terri Barnes. Special thanks are given to Sue Feasley who served as copy editor on the project. The responsibility for typesetting the manuscript fell to the Oklahoma State Department Communications Center under the direction of Jenny Fowler. Those involved in this project included Dona Landreth, Rose Primeaux, Leslie Mathis, Allison McLaughlin, and Gari Sha Robinson. The Art Department, under Carrie Williams, did the line drawings and graphics in the manuscript. Contributing artists included Regina Beaney, Gary Bradley, Kim Hale, Kathryn Hansen, Robert Randall, and Dana Welborne. The photographs were taken and printed by Dan Cole and Joan Henderson of the CIMC Media Unit. The final physical production is the work of the Oklahoma State Department Print Shop under the supervision of Noel Wilcoxson.

Our sincere appreciation to these people and the many others who made our work on this project easier but—more importantly—made the project a rewarding and enjoyable experience.

Kelly Sloan, CNC Production Instructor
Francis Tuttle Area Vo-Tech Center

Robert Hilley, Development Specialist
Curriculum and Instructional Materials Center

8

USE OF THIS PUBLICATION

Instructional Units

CNC Turning Technician includes six instructional units. A standard format was established in 1970 for development of instructional materials for all Oklahoma vocational teachers. This format includes eight basic components that form a unit of instruction: performance objectives, instructional overviews for the instructor, information sheets, assignment sheets, job sheets, instructor supplements, tests, and answers to tests and assignment sheets. Depending on the specific objectives, there may or may not be instructor supplements, assignment sheets, and job sheets included in the unit of instruction.

All of the unit components "zero in" on measurable and observable learning outcomes. Instructors are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the instructor will help him or her determine the following

A. Amount of material that can be covered in each class period

B. Skills that must be demonstrated
   1. Supplies and equipment needed
   2. Amount of practice needed
   3. Amount of class time needed for demonstrations

C. Supplementary materials, such as pamphlets and filmstrips, that must be ordered

D. Resource people who must be contacted

Performance Objectives (white pages)

Each unit of instruction is based on the performance needed for successful employment in an occupational area. Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction; and specific objectives, stating the performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching/learning process, it is important that instructors and students have a common understanding of the intent of the objectives. Following is a list of performance terms, their meanings, and behavioral synonyms that may have been used in this material.

A. Name — The individual supplies a name for objects, events, or people

   Behavioral synonyms: Label, list, letter, record, reiterate, repeat, write

B. Identify — The individual selects a named, described, or pictured object by pointing to it, touching it, picking it up, or selecting it

   Behavioral synonyms: Select, mark, match, choose, judge

C. State a rule — The individual communicates a relationship or principle that could be used to solve problems or perform a task

D. Apply a rule — The individual supplies an answer to a problem by using a stated relationship or principle

Behavioral synonyms: Solve, calculate

E. Describe — The individual relates sufficient characteristics or properties of an object or event so that a second individual will be able to state what is being discussed

Behavioral synonyms: Define, discuss, interpret, recite, tell how, tell what happens when

F. Distinguish — The individual selects an object or event from two or more that are easily confused

Behavioral synonyms: Discriminate, differentiate

G. Order — The individual arranges three or more objects or events in a sequence based on a stated property

Behavioral synonyms: Arrange, sequence, list in order, classify, divide, isolate, sort

H. Construct — The individual makes a physical object, a verbal statement, or a drawing

(NOTE: *Construct* is used when the finished product or result is important.)

Behavioral synonyms: Draw, make, build, design, formulate, reproduce, transcribe, convert, put together, compile

I. Demonstrate — The individual performs several operations necessary to carry out a specified process

(NOTE: *Demonstrate* is used when it is desirable to watch the student perform a task, one of the highest levels of student performance.)

Behavioral synonyms: Show your work, show procedure, perform an experiment, perform the steps, operate, remove, replace, turn off/on, (dis)assemble, (dis)connect

The objectives should be provided for students and stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods. Prepare for each unit by deciding how each objective can best be taught.

The objective sheet may also be used as a quick pretest to determine prior knowledge of students and to determine whether further study or activities are necessary. Instructors should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When changes in objectives are made, the instructor should remember to supply the needed information, assignment and/or job sheets, and criterion test items.

Instructional Overview (pink pages)

This component is included only in instructor material. The instructional overview assists the instructor during the preparation stage of the teaching/learning process by providing suggestions for delivery and/or presentation during the instructional process. Read the overview before teaching the units to allow time to obtain supplemental materials, prepare audio-visual materials, and contact outside resources. Duties of the instructor will vary according to the particular unit.

The instructional overview often includes materials for the teacher to use in supplementing the presentation. These may include transparency masters, student handouts, blueprints, computer program manuscripts, and other materials useful to the instructor.

Information Sheet (green pages)

The information sheet provides "must know" content essential for meeting the cognitive (knowledge level) objectives of the unit. The information is written in a topical outline form and is keyed to the specific objectives.

Instructors will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. The information sheet may also be used for coordination activities and advisory committees.

Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and instructors to add notes that supplement, localize, personalize, or provide motivation for each unit.

Assignment Sheets (brown pages)

Assignment sheets give students a chance at problem solving, self-assessment, and/or practical experience with the information. They assist students in the application of knowledges that are necessary prerequisites to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided when appropriate and can be used by the student and/or instructor for checking student progress.

Job Sheets (blue pages)

Job sheets are another important segment of a unit of instruction. The job sheets provide a list of equipment, tools, and materials needed to complete a manipulative or psychomoter skill. They describe a step-by-step procedure needed to complete each task or job. Diagrams, photographs, and illustrations are provided to assist students in achieving the skill.

The instructor should demonstrate to students the procedures outlined in each job sheet. Furthermore, the instructor needs to localize the job sheet according to the equipment and supplies available in the local lab or shop situation. Job sheets also furnish potential employers with a picture of the skills being taught and the performances they might reasonably expect from a person who has had this vocational instruction. Videotapes have been developed to demonstrate the procedures in a number of the job sheets for *CNC Turning Technician.*

Tests (yellow pages)

This component provides criterion-referenced evaluation of every objective listed in the unit of instruction. It is crucial to note that both paper/pencil and performance objectives must be evaluated.

The tests may be written or oral. The tests may be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of questions from the units covered may be used for final tests at the end of each term if desired. If objectives have been added, deleted, or modified, be sure to make the changes on the test.

The acceptable response on a unit test, 85 percent in most units, may be raised or lowered to fit the topic or students' ability levels. The percentage applies to the overall score, not to each individual question. The final unit grade should be obtained by using the paper/pencil score along with evaluations of student demonstrations of the desired skills.

Answers to Test and Assignment Sheets (pink pages)

These components are designed to assist the instructor in evaluation of student performances.

Page Numbering

Each publication from the Curriculum and Instructional Materials Center is assigned a specific abbreviation. For example, *CNC Turning Technician* has been abbreviated CNC. The units are then numbered consecutively. Since CIMC publications are loose leaf, this system of page numbering was adopted so that pages from different manuals would not get mixed up.

Methods of Disseminating Material

Material may be given out a unit or page at a time to keep the material before the student always new. Some instructors ask students to furnish a three-ring binder for the units. This is convenient for taking the materials home to study. Upon completion, each unit is then placed in a larger binder. The large binders may be purchased at cost from the CIMC. Some instructors store the materials by units in filing cabinets or boxes until needed. All the units may be given out at once if desired.

For best results, provide student materials for each student. Student materials contain everything but the test answers, answers to assignment sheets, and instructional overviews. All tests are collated at the back of student material and should be removed and stored until needed. Students should be allowed to take their materials home at the end of the course.

Teaching Methods

It is a challenge to keep students motivated. Supplement the objectives by providing the "why," personal experiences, and current information. Prepare for each unit by deciding how each objective can best be taught. Allow students to become involved in preparing and planning.

Competency Profiles

Competency profiles are folders used to document student performance. The profile contains a list of the specific job competencies that should be achieved prior to leaving the training program.

CORRECTIONS AND SUGGESTIONS

The Curriculum and Instructional Materials Center wants to provide vocational instructors and students with materials that are accurate and effective. Although the Center strives to maintain the highest standards of development and production, oversights occasionally do occur. If you find any errors in this or other CIMC publications, or have suggestions for improving their usefulness in vocational programs, please notify the CIMC staff. One easy way of pointing out errors is to make a photocopy of the affected page and to indicate the correction on the copy. You can then mail the information to the CIMC, where it will be used to correct the publication before the materials are reprinted.

To ensure that the material is updated on a timely basis, it is important that you notify the Center of necessary corrections as soon as possible after discovering the error. Do not assume that someone else will notice the error and inform the CIMC; other users may be making the same assumption. Please send corrections and recommendations for improving this publication to the following address:

Assistant Coordinator for Development
Curriculum and Instructional Materials Center
Oklahoma State Department of Vocational and
Technical Education
1500 West Seventh Avenue
Stillwater, Oklahoma 74074

PERFORM PREVENTIVE MAINTENANCE
UNIT I

UNIT OBJECTIVE

After completing this unit, the student should be able to perform preventive maintenance on the Baxter Vo-Tec 2000 Future Builder CNC Lathe and similar equipment. The student will show this knowledge by completing assignment sheets, job sheet, and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with preventive maintenance to their correct definitions.
2. Select from a list facts concerning numerical control.
3. Match jobs in shops using CNC lathes to their major responsibilities.
4. Label work areas of the Baxter Vo-Tec 2000 Future Builder CNC Lathe.
5. Label major parts of the Baxter Vo-Tec 2000 Future Builder CNC Lathe.
6. Select from a list facts concerning the Cartesian coordinate system.
7. Label the axes on a CNC lathe.
8. Match types of lubricants used in lathes to their correct descriptions.
9. Label coordinate points.
10. Determine required lubricants and coolants.
11. Demonstrate the ability to perform routine inspection and maintenance.

PERFORM PREVENTIVE MAINTENANCE
UNIT I

INSTRUCTIONAL OVERVIEW

I. Unit contents

   A. Objective sheet

   B. Instructional overview (instructor copy)

   C. Instructional supplements (instructor copy)

      1. Transparency Master #1 — Everyday Computers

      2. Transparency Master #2 — Work Areas of the Baxter Vo-Tec 2000 Future Builder CNC Lathe

   D. Information sheet

   E. Assignment sheets

      1. Assignment Sheet #1 — Label Coordinate Points

      2. Assignment Sheet #2 — Determine Required Lubricants and Coolants

      3. Assignment Sheet #3 — Complete Preventive Maintenance Inspection Checklist

   F. Answers to assignment sheets (instructor copy)

   G. Job sheet #1 — Perform Routine Inspection and Maintenance

   H. Test

   I. Answers to test (instructor copy)

II. Suggested activities

   A. Review unit of instruction and plan method of presentation.

   B. Obtain materials necessary to supplement unit.

   C. Make transparencies.

INSTRUCTIONAL OVERVIEW

D. Introduce students to CNC training.

(NOTE: The material covered in this program will be useful to secondary and vocational training students, experienced machinists wishing to be proficient on CNC equipment, machine shop supervisors needing to become familiar with technological advances in the field, and many other diversified groups. Tailor your instructional and motivational techniques to meet the specific needs of your students.)

SUGGESTIONS:

- Tour an industry using CNC equipment or demonstrate a production run on CNC equipment in your shop.
- Invite a representative from an industry using CNC equipment to discuss advantages of such machines over conventional equipment.
- Make a bulletin board or other display showing the CNC equipment available from various manufacturers.

E. Relieve any fears or negative feelings the students may have about advanced technology.

(NOTE: Many people are intimidated by modern technology, especially computers. Many see advances in automation as threats to their own jobs. Others may feel that the use of computerized controls detracts from the craftsmanship of machined products. These are feelings that you can expect to encounter with students from various backgrounds, and you must plan to overcome any fears or negative attitudes toward modern technology.)

SUGGESTIONS:

- Point out how common the computer has become in our daily lives — automotive computers, personal computers, automated banking, and video games.
- Use a pocket calculator and Transparency #1 to demonstrate the basic functions of a computer: input, memory, and output; emphasize that the pocket calculator is just as much of a computer as that used in CNC equipment, except that it has less memory capability and fewer functions.
- Have students discuss their personal experiences with computers and direct discussion toward positive attitudes.

INSTRUCTIONAL OVERVIEW

- Point out that the accuracy of computerized controls is dependent on the operator and the programmer and that basic machinist skills are still required to be a good CNC machine operator; emphasize that computers are just tools added to machining equipment to improve accuracy and efficiency.

F. Provide students with unit of instruction.

(NOTE: You may choose to give the students parts of a unit as you cover them in class, each unit as you begin to cover the material, or all six of the units as you begin the course. Student copies and additional instructor copies may be obtained by contacting your Baxter Technologies representative or the home office or through the Oklahoma State Department of Vocational and Technical Education. Addresses can be found on page ii of this manual.)

G. Discuss unit and specific objectives.

H. Discuss information sheet.

1. Use Section I of the information sheet to discuss terms associated with computerized numerical control turning; have examples of the parts and materials discussed to show the class.

2. Use Section II of the information sheet to provide the students with background information on numerical control.

SUGGESTIONS:

- Make articles and books available to the class to allow further reading on the subject.
- Ask company representatives to display their NC and CNC equipment and discuss the future of such systems.
- Update statistics given or try to obtain similar information for your region.

3. Use Section III of the information sheet to discuss positions available in shops using CNC lathes and to provide the students with an overview of the course.

SUGGESTIONS:

- Emphasize how the information, procedures, and learning activities in this course are directly related to industry needs.
- Ask persons working in the various CNC lathe jobs or company representatives from industries using CNC lathes to discuss the job titles and responsibilities used in their company.

INSTRUCTIONAL OVERVIEW

4. Use Section IV of the information sheet to introduce the class to the Baxter Vo-Tec 2000 Future Builder CNC Lathe.

5. Use Section V of the information sheet to discuss machine parts and components in the various work areas.

SUGGESTIONS:

- Give a guided discussion using the Future Builder in your shop; emphasize the parts covered in the information sheet and discuss other components that seem appropriate for the class.

  (NOTE: Do not go into too much detail at this point on the functional capabilities or the subparts of each component, such as all the keys on the GN3T Control, unless your students are familiar with such equipment. It is important not to overwhelm the students at this point; they will gain confidence and become ready for additional information as you continue the course.)

- Use the machine specifications to assure the class that the Future Builder is a production-quality lathe and not just a toy model good only for training.

- Show the class samples of the hammer or other machined products that they will produce during the course.

  a. Emphasize the parts that are major areas of concern when inspecting the machine and performing preventive maintenance.

  b. Point out all gauges and all areas requiring lubrication or coolant.

  c. Emphasize that most of the mechanical parts of CNC equipment are identical or similar to conventional equipment and that the rules for safety and upkeep are important in machine operation.

6. Use Section VI of the information sheet to discuss the Cartesian coordinate system.

SUGGESTIONS:

- Construct a three-dimensional model of coordinate planes to help clarify the concepts.

- Display planning drawings and programs with coordinate points labeled to explain why an understanding of this system will be used in CNC turning.

INSTRUCTIONAL OVERVIEW

7. Use Section VII of the information sheet to relate Cartesian axes to the CNC lathe.

SUGGESTIONS:

- Point out the axes on the actual machine.
- Demonstrate movements along the axes, emphasizing the correlation between joystick positions, turret movement, and CRT displays.
- Allow students a little hands-on experience by making short manual movements along the axes.
- Demonstrate point locations using a part drawing.
- Use Assignment Sheet #1 to allow students to practice identifying coordinate points.

8. Use Section IV of the Information Sheet to discuss lubricants.

SUGGESTIONS:

- Have samples of the various lubricants available for the students to see.
- List trade names and acceptable equivalents of each type of lubricant.
- Provide students with the Future Builder maintenance manual and point out the location of lubrication charts and instructions; use Assignment Sheet #2 to allow the students a chance to become familiar with lubricant requirements.
- Demonstrate the inspection procedures outlined in Job Sheet #1 and then allow the students to practice the procedures using the Job Sheet.
- Show videotape program "Perform Routine Inspection and Maintenance."
- Show the class examples of failed gears and other parts damaged as a result of neglect.
- Discuss safety practices and the effects of neglecting care and maintenance on the safe operation of the machine.

I. Give test.

(NOTE: The complete test consists of the written portion and the student's demonstration of skills.)

INSTRUCTIONAL OVERVIEW

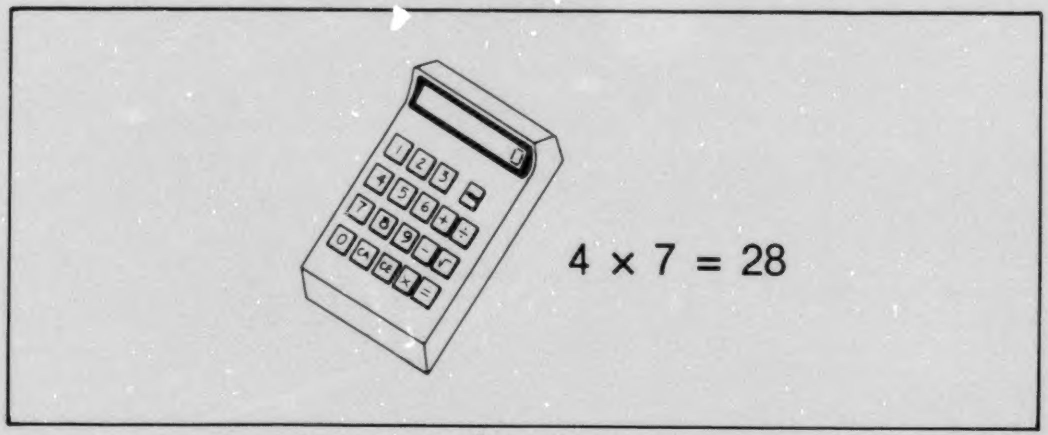
SUGGESTIONS:

- After grading written portion of test, allow students to perform inspection using Assignment Sheet #3.

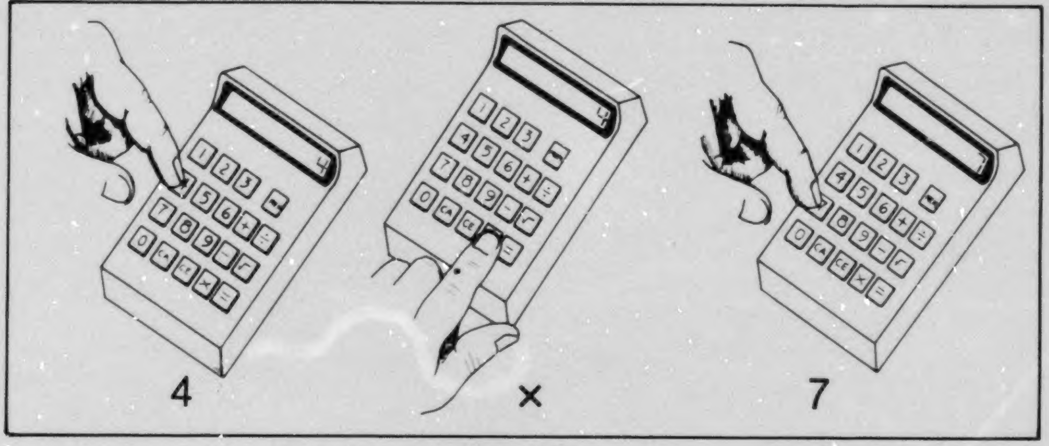
- Set up problems, such as low fluid levels or loose air line connections, for the students to find during their inspections.

J. Reteach and retest if necessary.

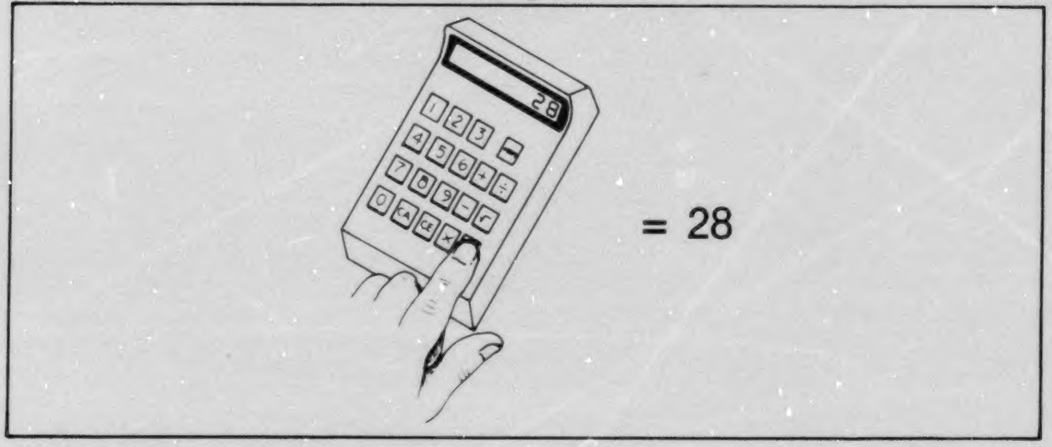
Everyday Computers



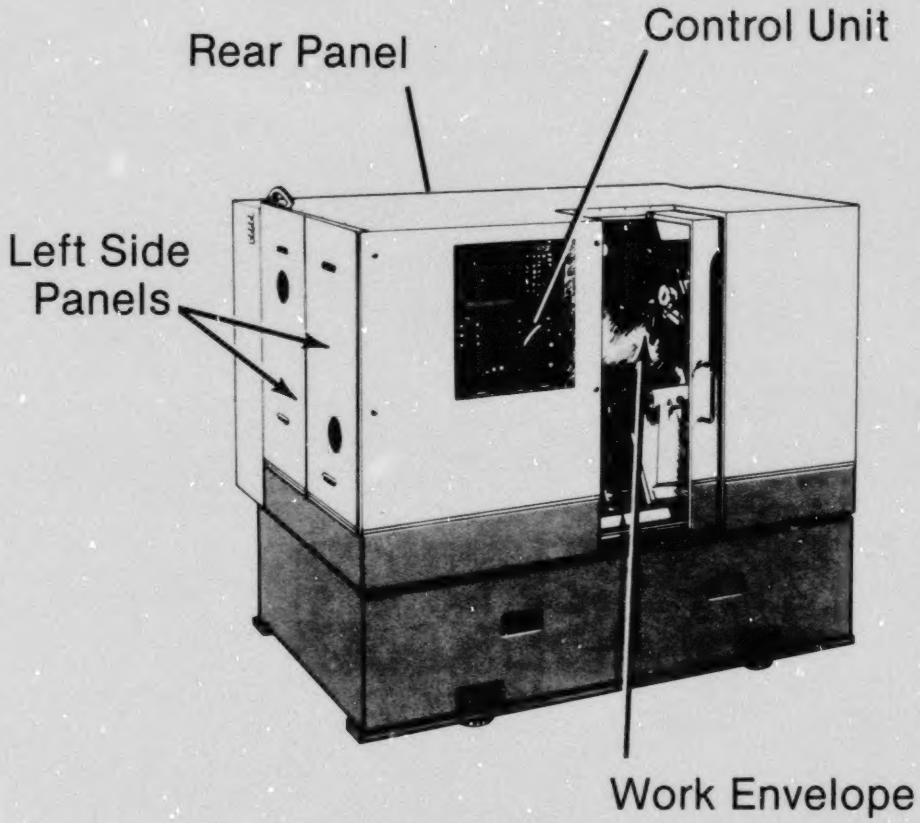
Input



Output



Work Areas of the Baxter Vo-Tec 2000 Future Builder CNC Lathe


Rear Panel
Control Unit
Left Side Panels
Work Envelope

PERFORM PREVENTIVE MAINTENANCE
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Coolant — Mixture of water and chemicals used to provide cooling and lubrication during machining

B. Emergency stop (E-stop) — Switch that can be depressed to stop all machine functions immediately

C. Servomotors — Electric motors that allow extremely precise movements of the X and Z axes

D. Ball screw — Large threaded shaft that connects the servomotors to the saddle to allow motion of the X and Z axes

E. Slide ways — Precisely ground rods or rails on which the turret and saddle ride

F. Control unit — Computerized portion of CNC machine including the computer memory and input and output devices

G. Cathode ray tube (CRT) — Display screen used to provide user with information from the control unit

EXAMPLES: Tooling positions on programs, user commands, location of stored information

H. Tape reader — Device used to read a numerical control (NC) tape in order to feed the tape information into the control unit or to operate machine directly from NC tapes

(NOTE: NC tapes are one of four ways of putting information into the control memory. All of these methods will be discussed in detail in a later unit.)

I. Main disconnect switch — Switch used to remove all power to the machine

J. Chip conveyor — Mechanical device used to transport chips from the machine and into a storage bin

(NOTE: The chip conveyor is optional on the Future Builder.)

K. Safety guards — Protective devices and covers placed around various parts of the machine to protect the user or to prevent accidental contact with switches and other parts

L. Air line water separator — Device to remove water from the air lines used in the system

INFORMATION SHEET

M. Backlash — Amount of clearance between ball screw and ball nut

(NOTE: Backlash is also called *play* or *slop*.)

II. Facts concerning numerical control (NC)

(NOTE: Numerical control has been used in machining for several years. In 1952, the Massachusetts Institute of Technology produced the first such machine, a three-motion milling machine manufactured in response to the need to produce aircraft parts with very close accuracy and reliable consistency. Presently, more than 9,000 manufacturing plants in the United States use NC equipment, but the Society of Manufacturing Engineers has estimated that there are an additional 30,000 plants that could profitably use NC applications. That number will continue to grow with advances in technology and reductions in the costs of such equipment.)

A. Uses a code of numbers and letters to control machine operations

(NOTE: The code is often in the form of holes punched into tape. The machine "reads" the holes and responds to those commands by performing the operations and movements contained in the coded information.)

B. Allows consistent repetition of an operation

(NOTE: One of the greatest advantages of NC applications is in the manufacture of many copies of a given part. Numerical control allows the machine to repeat exactly the motions and operations determined by the program in the production of a part.)

C. Reduces production time

(NOTE: NC production requires more time in planning and producing the NC control devices, and often requires more time for setting up the equipment. However, this is usually offset by the great reduction in actual machining time.)

D. Can be used with a computer to provide greater flexibility and improved accuracy

(NOTE: The use of an internal computer with numerical control is called computerized numerical control or CNC. Sometimes an external computer is used to control the machine directly; this application is called direct numerical control or DNC. Currently, rapid advances are being made in computer-assisted design [CAD] and computer-assisted manufacturing [CAM]. These advances greatly increase the need for qualified CNC operators and programmers.)

INFORMATION SHEET

III. Jobs in shops using CNC lathes

(NOTE: The duties and titles of individuals working in shops with CNC lathes will vary with each particular shop and the production procedures used in the shop. Some duties may overlap or be performed by a person with a title other than those given. These occupations are listed here as representative of the kinds of employment opportunities and skills required in the trade.)

A. CNC lathe start-up person — Responsible for performing routine maintenance inspection and powering up of the machine in preparation for production

(NOTE: Units I and II of this course cover the concepts and skills that are normally required of a start-up person.)

B. CNC lathe set-up person — Responsible for interpreting work orders and setup sheets in order to load programs and set up tooling required for a specific production operation; may be required to perform inspections and power up machine

(NOTE: Unit III covers the additional concepts and skills required of a set-up person.)

C. CNC lathe operator — Responsible for operating machine and making necessary inspections and adjustments during the production process; may be required to power up and set up machine

(NOTE: Units IV and V cover the additional concepts and skills required of a CNC lathe operator.)

D. CNC turning programmer — Responsible for writing programs to be used in CNC lathe computers for part production

(NOTE: Unit VI covers the additional concepts and skills required of a CNC turning programmer.)

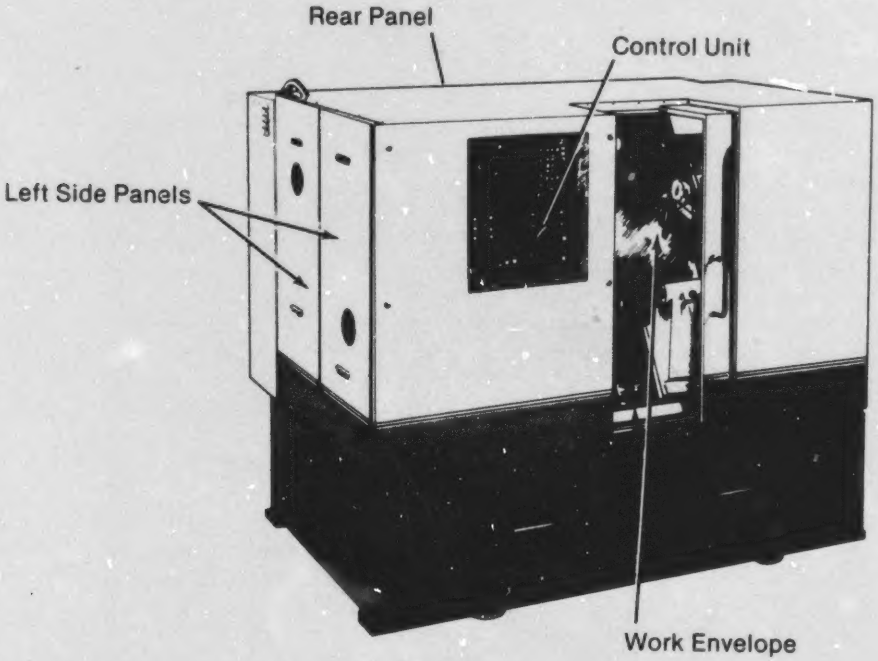
E. CNC turning technician — Responsible for performing all tasks associated with CNC turning

(NOTE: Successful completion of all training areas in this course leads to qualification as a CNC turning technician.)

INFORMATION SHEET

IV. Work areas of the Baxter Vo-Tec 2000 Future Builder CNC Lathe

FIGURE 1

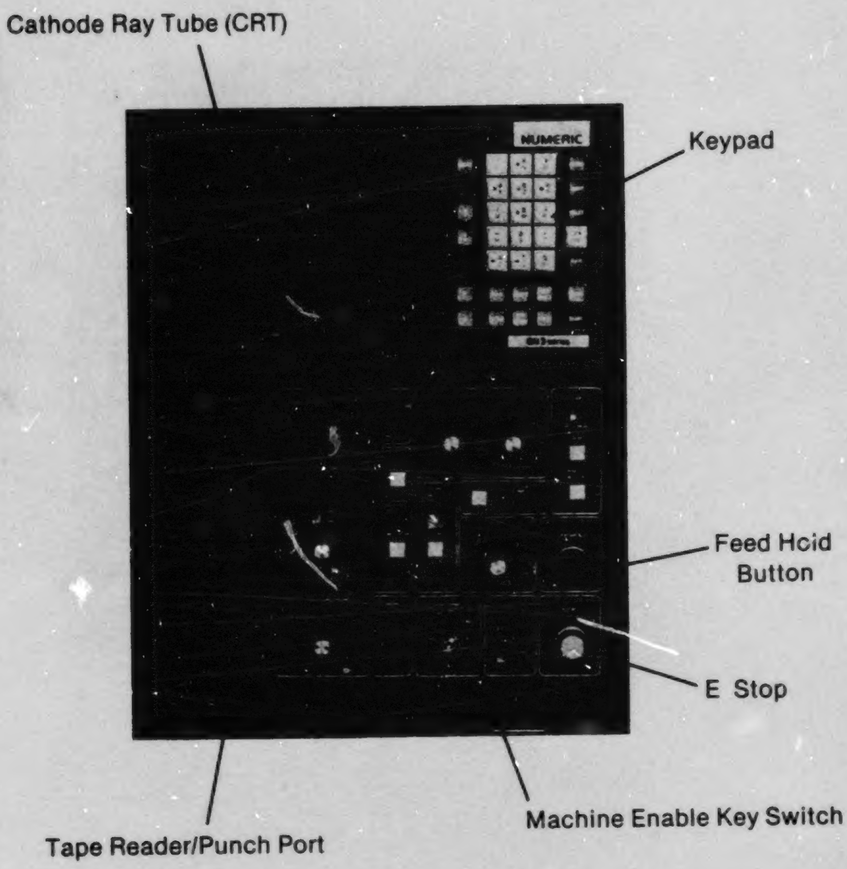

Rear Panel
Control Unit
Left Side Panels
Work Envelope

INFORMATION SHEET

V. Major parts of the Baxter Vo-Tec 2000 Future Builder CNC Lathe

A. Control unit (Figure 2)

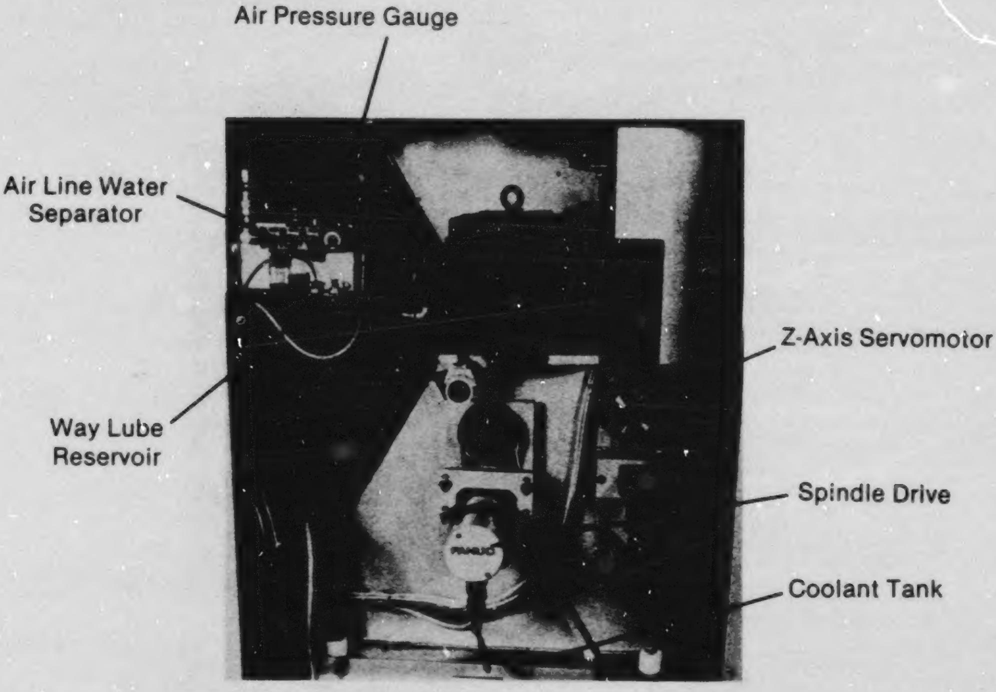
FIGURE 2


Cathode Ray Tube (CRT)
NUMERIC
Keypad
Feed Hold Button
E Stop
Machine Enable Key Switch
Tape Reader/Punch Port

INFORMATION SHEET

B. Left side panels (Figure 3)

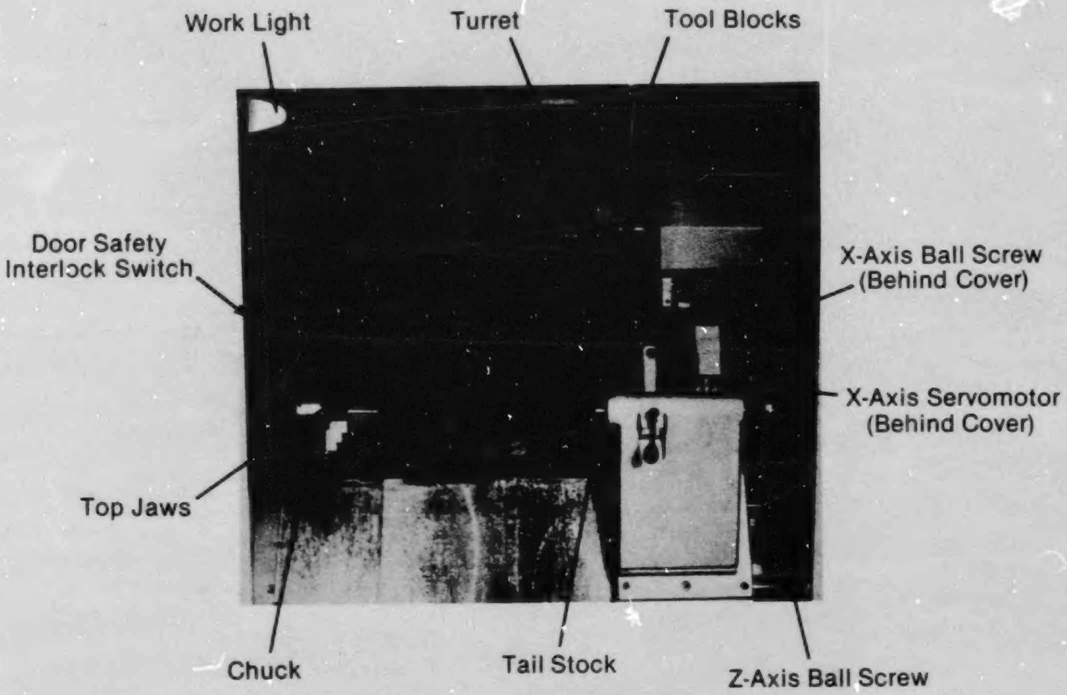
FIGURE 3


Air Pressure Gauge
Air Line Water Separator
Way Lube Reservoir
Z-Axis Servomotor
Spindle Drive
Coolant Tank

INFORMATION SHEET

C. Work envelope (Figure 4)

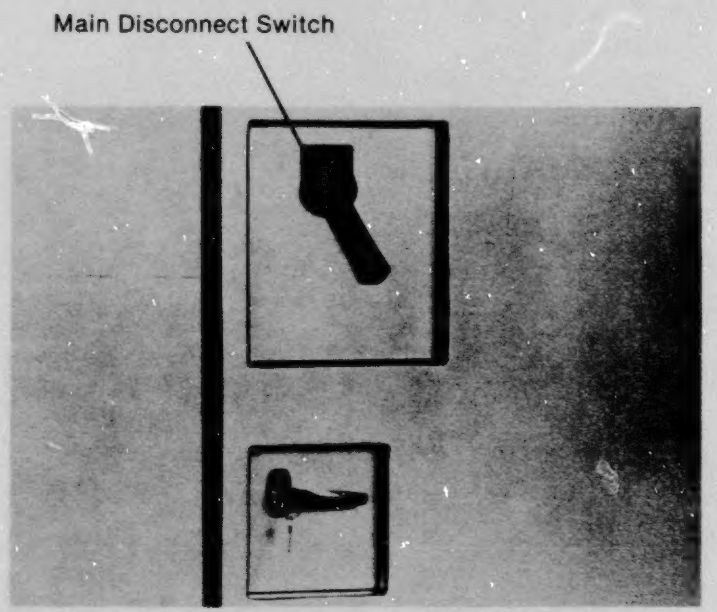
FIGURE 4


Work Light
Turret
Tool Blocks
Door Safety Interlock Switch
X-Axis Ball Screw (Behind Cover)
X-Axis Servomotor (Behind Cover)
Top Jaws
Chuck
Tail Stock
Z-Axis Ball Screw

INFORMATION SHEET

D. Rear panel (Figure 5)

FIGURE 5



VI. Cartesian coordinate system

(NOTE: The Cartesian coordinate system is a means of identifying points within a given space, such as the work envelope of a CNC lathe. The system, also known as rectangular coordination, allows a CNC technician to communicate with the machine to specifically locate tools and features of a part. For example, using Cartesian coordinates, the location of a tool point may be identified or the location of a shoulder on a part can be defined in relationship to the space in the work envelope.)

A. Cartesian coordinate axes

(NOTE: An axis is a real or imaginary line around which an object rotates or around which objects or points are evenly arranged. For example, a wheel rotates on an axle; the centerline of that axle is the axis of rotation for the wheel. In the Cartesian coordinate system, an axis is a line used to reference locations of points. The plural of *axis* is *axes*.)

INFORMATION SHEET

1. X axis — Horizontal line running to the viewer's left and right in establishing a set of Cartesian coordinates (Figure 6)

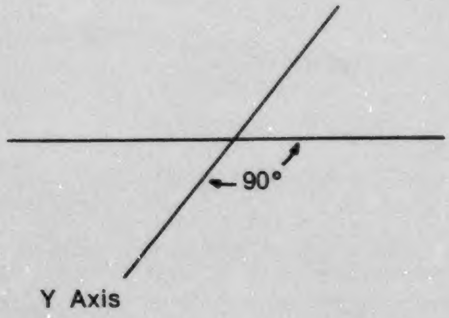
   EXAMPLE:

   FIGURE 6

2. Y axis — Horizontal line running toward and away from the viewer and intersecting the X axis at a right angle in establishing a set of Cartesian coordinates (Figure 7)

   EXAMPLE:

   FIGURE 7

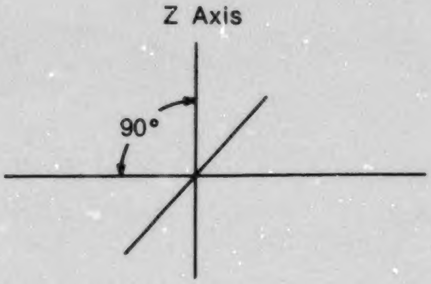


INFORMATION SHEET

3. Z axis — Vertical line intersecting the X and Y axes at a right angle in establishing a set of Cartesian coordinates (Figure 8)

   EXAMPLE:

   FIGURE 8



   (NOTE: In some systems, the Y and Z labels may be opposite from those shown here. However, in the machining industry, the axes are generally labeled as indicated above.)

B. Cartesian coordinate planes

1. All the lines that can be made parallel to a given axis and intersecting one other axis at right angles form a plane

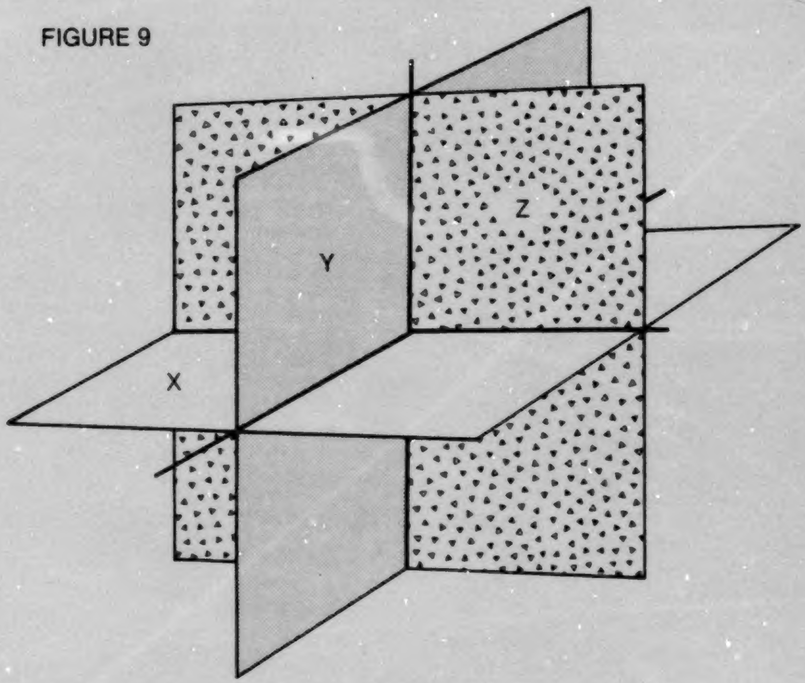
   (NOTE: Because a line in geometry is defined as a set of points, a plane consists of all the points in the lines that are in that plane.)

INFORMATION SHEET

2. There is one plane for each axis (Figure 9)

EXAMPLE:

FIGURE 9



C. Cartesian coordinate points

1. The intersection of the three axes is considered to be the zero point in the Cartesian coordinate system

2. All points along the axes can be labeled using a unit of measurement

   (NOTE: In machining, the unit of measurement is usually inches or millimeters.)

3. A point other than zero will have either a positive (+) or negative (-) value (Figure 10)

   a. Points to the right of the zero point on the X axis are positive; points to the left are negative

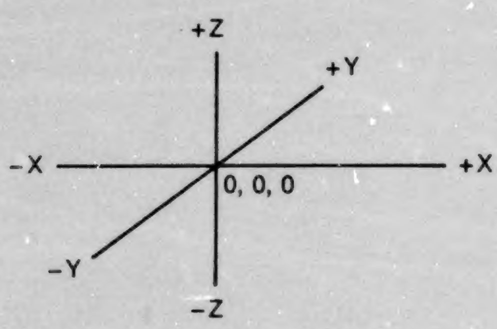
   b. Points on the side of zero away from the viewer on the Y axis are positive; points on the same side of the zero as the viewer are negative

INFORMATION SHEET

c. Points above the zero point on the Z axis are positive; points below zero are negative

EXAMPLE:

FIGURE 10



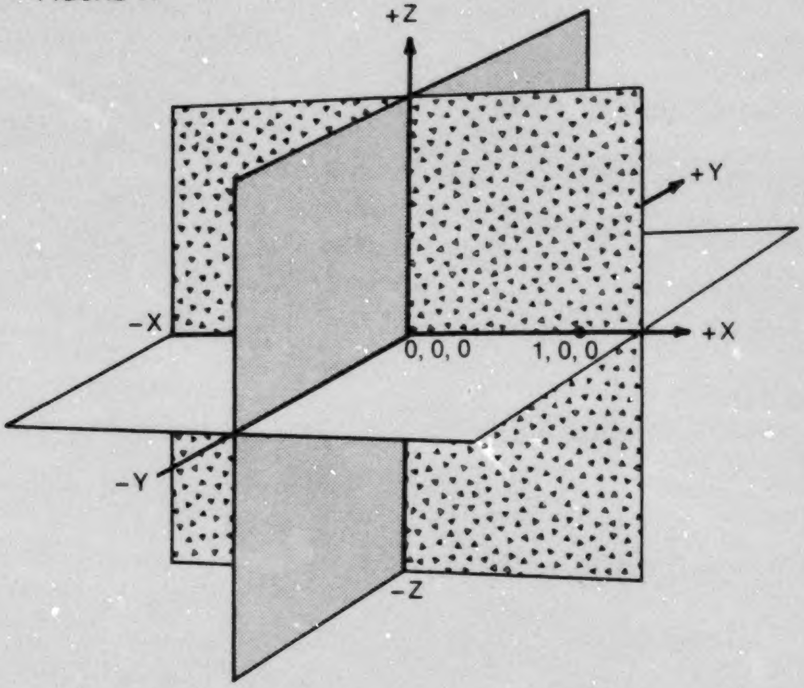
INFORMATION SHEET

4. Any point can be labeled using the X, Y, and Z values for that point

   (NOTE: Although the points along the axes have been spoken of in terms of how they are seen by the viewer, the labeling of the axes does not change once established even if the viewer changes positions relative to the coordinate point.)

   EXAMPLES: a. A point one inch to the right of zero on the X axis can be labeled 1,0,0 (Figure 11)

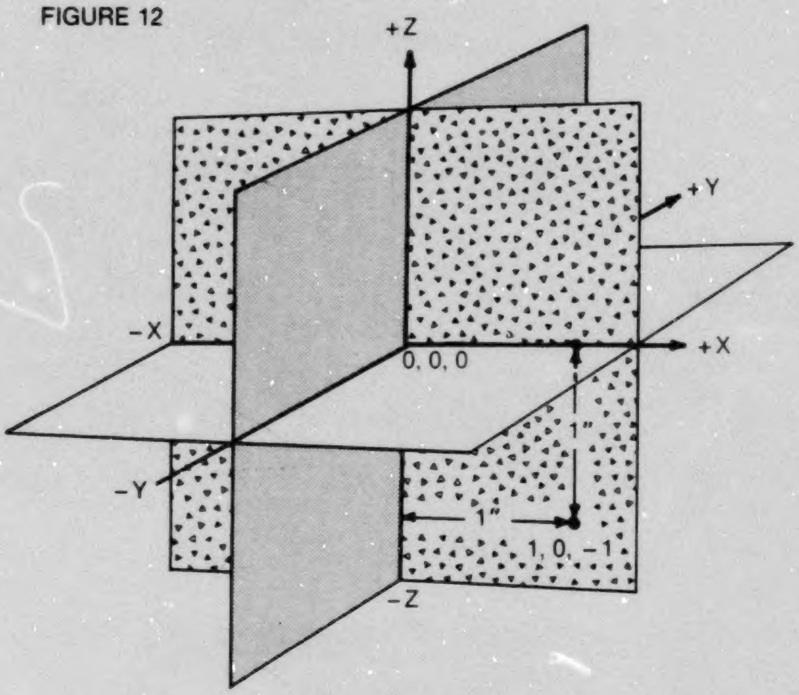
FIGURE 11



INFORMATION SHEET

b. A point one inch to the right of zero along the X axis and one inch below the zero along the Z axis can be labeled 1,0,-1 (Figure 12)

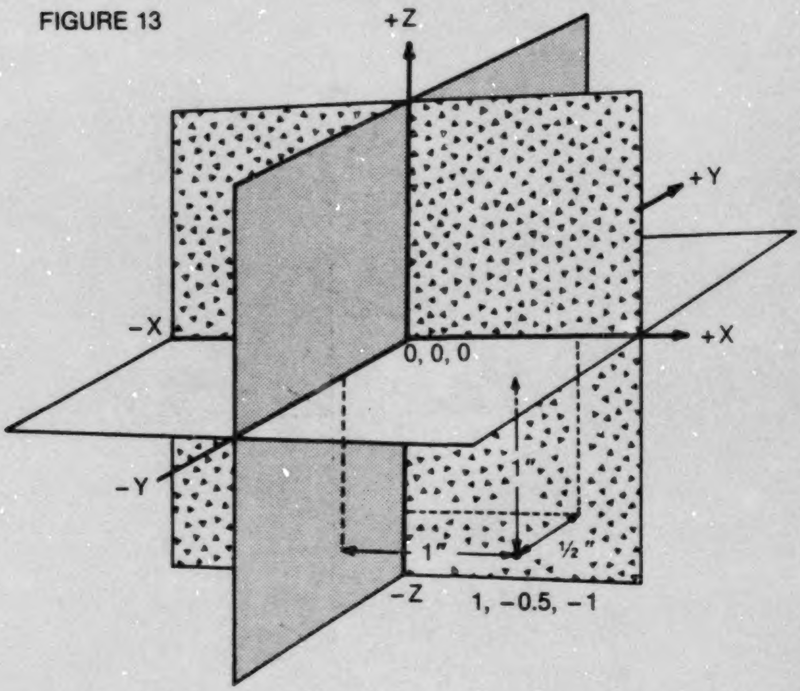
FIGURE 12



INFORMATION SHEET

c. A point one inch to the right of zero along the X axis, one inch below the zero along the Z axis, and one-half inch toward the viewer along the Y axis can be labeled 1,-0.5,-1 (Figure 13)

FIGURE 13



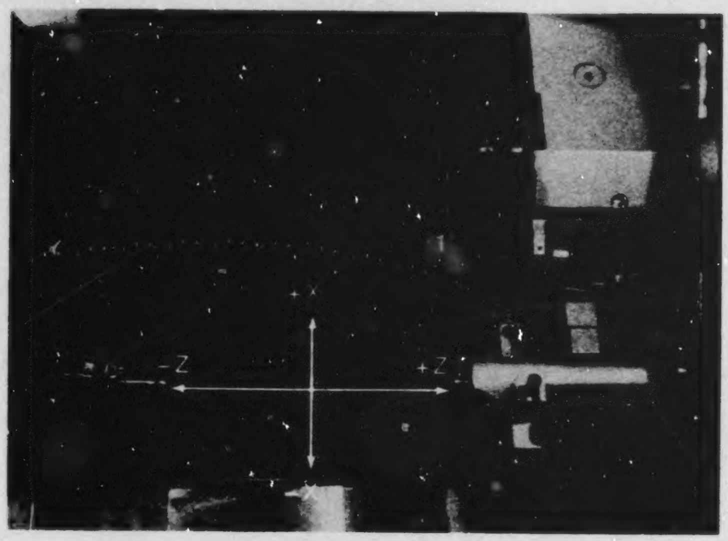
VII. Axes for a CNC lathe (Figure 14)

(NOTE: The axes for a machine are usually determined in relationship to the normal position of the operator as the viewer. Once established, the machine axes do not change.)

A. Z axis runs along center line of spindle

B. X axis runs at right angle to Z axis and parallel to cross slide

(NOTE: On most CNC lathes, there is no movement along the Y axis of either the part or the tools during machining. For that reason, only the X and Z axes are of importance to CNC turning technicians.)



VIII. Types of lubricants used in lathes and their descriptions

(NOTE: Always refer to the manufacturer's maintenance manual for the correct weight and type of lubricant.)

A. Way oil — Medium weight oil used to lubricate the slide ways

B. Hydraulic oil — Light weight oil used in hydraulic system to power spindle and other components

(NOTE: The Baxter Future Builder does not use hydraulic oil.)

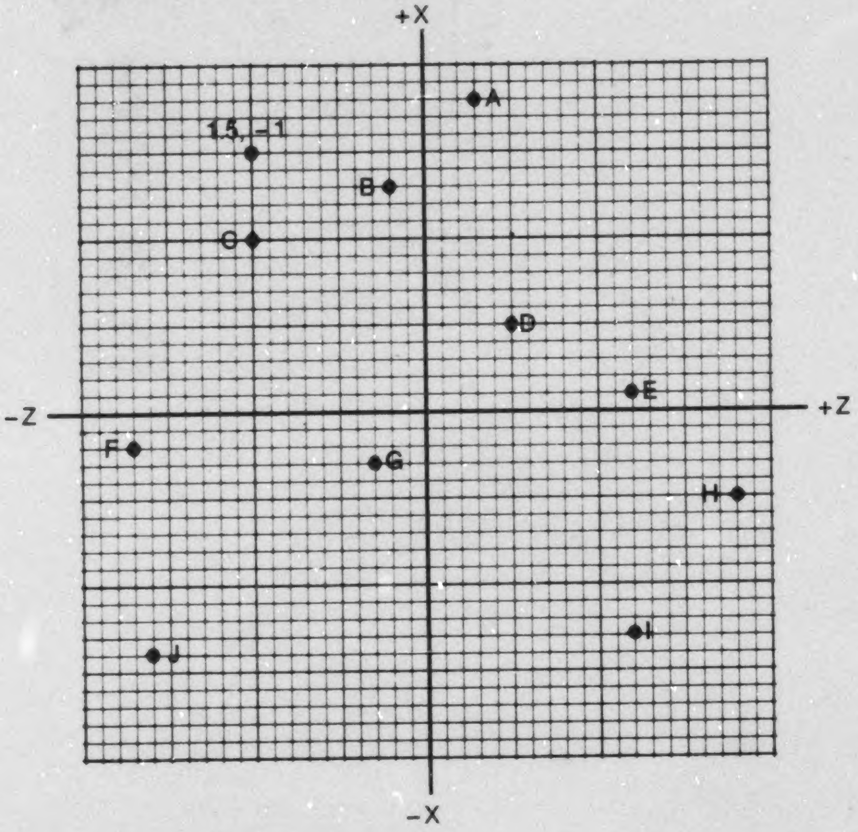
C. Machine oil — Light to medium weight oil used to lubricate moving machine parts such as the headstock and spindle

PERFORM PREVENTIVE MAINTENANCE
UNIT I

ASSIGNMENT SHEET #1 — LABEL COORDINATE POINTS

NAME ______________________________ SCORE ______________

To understand the operation of CNC lathe components such as the X and Z axes servomotors and to begin to understand the language of CNC programming, you need to become familiar with the Cartesian coordinate system and be able to label points using that system. Because CNC turning is generally limited to using the X and Z axes, you should practice labeling points in terms of their X and Z values. Study the graph below and label the lettered points. Consider each grid line of the graph as one-tenth of an inch with the half-inch and inch grids accented with heavier lines. Use one inch as your unit of measurement. An example has been done for you.



A. ____________

B. ____________

C. ____________

D. ____________

E. ____________

F. ____________

G. ____________

H. ____________

I. ____________

J. ____________

PERFORM PREVENTIVE MAINTENANCE
UNIT I

ASSIGNMENT SHEET #2 — DETERMINE REQUIRED LUBRICANTS AND COOLANTS

NAME ________________________________ SCORE ____________

The good machinist realizes that proper maintenance of tools and equipment is essential to quality work. As an example, failure to properly lubricate a lathe spindle will lead to excessive wear in the spindle bearings. Worn bearings affect the speed and the center of rotation, thus leading to inaccuracies in the turning operation. Proper lubrication also means that the machine will last longer and operate more efficiently. Remember always that CNC controls are largely just attachments to standard machine shop equipment. Most of the tooling and mechanical parts of CNC systems are basically the same as conventional machinery and require proper maintenance.

The machinist's source of information regarding proper lubricants is the maintenance manual provided by the machine manufacturer. Use the maintenance manual for the Baxter Vo-Tec 2000 Future Builder CNC Lathe or a manual provided by your instructor for any other lathe to answer the following questions about lubrication and coolant requirements.

A. Coolant

1. How often is the coolant to be checked? ____________________

   ____

2. What indication tells that additional coolant should be added? __________

   ____

3. What type of coolant and what mixture of coolant and water is used in your shop?

   ____

B. Air line water separator lubricant

1. How often should the air line water separator lubricant be checked? ________

   ____

2. What indication tells that additional air line water separator lubricant should be added?

   ____

3. What type of lubricant should be used in the air line water separator? ______

   ____

ASSIGNMENT SHEET #2

4. What are the brand name and specifications of one product that could be used to lubricate the air line water separator?

   ____

C. Way and ball oil

1. How often should the way and ball oil be checked? ____________

   ____

2. What indication tells that additional way and ball oil should be added? ______

   ____

3. What type of lubricant should be used on the slide ways and ball screws? ___

   ____

4. What are the brand name and specifications of one product that could be used to lubricate the slide ways or ball screws?

   ____

D. Spindle oil

1. How often should the spindle oil be checked? ____________

   ____

   ____

2. What indication tells that additional spindle oil should be added? ________

   ____

3. What type of lubricant should be used for the spindle? ____________

   ____

   ____

4. What are the brand name and specifications of one product that could be used to lubricate the spindle?

   ____

ASSIGNMENT SHEET #2

E. Turret oil

1. How often should the turret oil be checked? ____________________

   ____

2. What indication tells that additional turret oil should be added? __________

   ____

3. What type of lubricant should be used for the turret? ______________

   ____

4. What are the brand name and specifications of one product that could be used to lubricate the turret?

   ____

PERFORM PREVENTIVE MAINTENANCE
UNIT I

ASSIGNMENT SHEET #3 — COMPLETE PREVENTIVE MAINTENANCE INSPECTION CHECKLIST

NAME ____ SCORE ________________

Many companies place such importance on the proper maintenance of equipment that machine operators are required to keep records of their inspections and service of the machines. The checklist will vary from machine to machine and from company to company, but the one in this assignment sheet is typical of what an inspection sheet for a CNC lathe might look like. Perform a routine inspection of a CNC lathe in your shop and complete the following inspection checklist or one provided by your instructor.

ASSIGNMENT SHEET #3

Preventive Maintenance

DAILY (EACH SHIFT) CHECK LIST

NOTE: This checklist is intended as a guide only and is not to be interpreted as all inclusive. Good maintenance and shop housekeeping practices must be observed in order to obtain maximum trouble-free operation.

NAME ______________________ MACHINE NO. ______________________

SHIFT ______________________ DATE ______________________

		S	M	T	W	T	F	S
1. CHECK OIL LEVEL (ADD AS REQUIRED)								
AIR LINE WATER SEPARATOR								
WAY LUBE								
SPINDLE								
TURRET								
ADDITIONAL OIL RESERVOIRS ON OPTIONAL EQUIPMENT								
LUBRICATE IN ACCORDANCE WITH DAILY REQUIREMENTS								
2. CHECK PRESSURE GAUGES FOR PROPER READING PNEUMATIC SYSTEM (80-90 PSI)								
3. CLEAN CHIPS AND FOREIGN MATTER FROM SLIDES AND SWITCHES								
4. CHIP PAN CLEANED	YES							
	NO							
5. MACHINE AND CABINET WIPED DOWN	YES							
	NO							
6. CABINET VENTILATING FAN OPERATING	YES							
	NO							
7. EXERCISE SLIDES MANUALLY, LONGEST POSSIBLE TRAVEL,								
CHECK FOR PROPER LUBRICATION								
CHECK FOR NORMAL SLIDE OPERATION								
8. VISUALLY INSPECT ALL TOOLS								
9. CHECK THAT ALL GUARDS ARE IN PLACE AND THAT CONTROL DOORS ARE SHUT AND PROPERLY SECURED								
10. CHECK COOLANT — SUPPLY IN RESERVOIR								
— FLOW TO TURRET								
11. CHECK CONTROL UNIT FOR ALARMS IF POWERED UP								
12. RECORD AND FORWARD ANY MALFUNCTION TO PROPER PERSONNEL								

— NOTES —

PERFORM PREVENTIVE MAINTENANCE
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

A.	1.8, 0.3	F.	-0.2, -1.2
B.	1.3, -0.2	G.	-0.3, -0.3
C.	1.0, -1.0	H.	-0.5, 1.8
D.	0.5, 0.5	I.	-1.3, 1.2
E.	0.1, 1.2	J.	-1.4, -1.6

Assignment Sheet #2 — Evaluated to the satisfaction of the instructor

Assignment Sheet #3 — Evaluated to the satisfaction of the instructor

PERFORM PREVENTIVE MAINTENANCE
UNIT I

JOB SHEET #1 — PERFORM ROUTINE INSPECTION AND MAINTENANCE

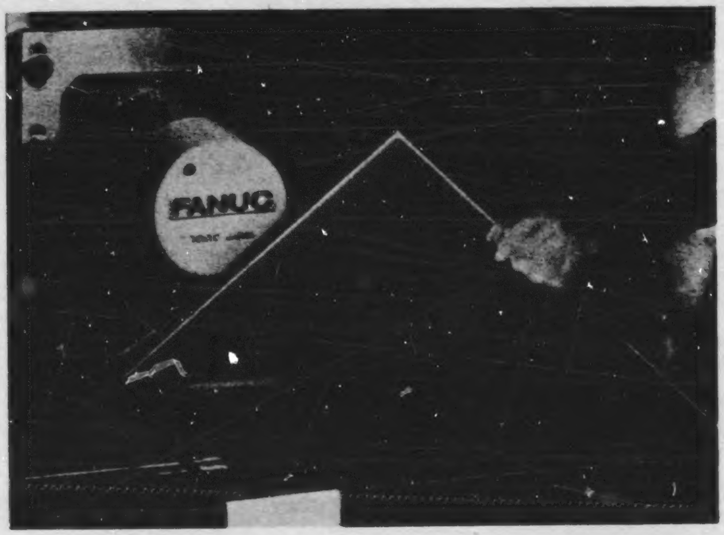
I. Equipment and materials

- A. CNC lathe
- B. CNC lathe maintenance manual
- C. Coolant and lubricants as required
- D. Shop towels
- E. Assorted wrenches

II. Procedure

- A. Check to see that main power disconnect switch is off
- B. Remove left side panels of machine
- C. Check coolant level
  - 1. Lift coolant tank lid (Figure 15)

FIGURE 15



2. Check to see that tank is at least half full; add coolant if required

   (NOTE: Coolant should be mixed with water at ratio specified by coolant manufacturer.)

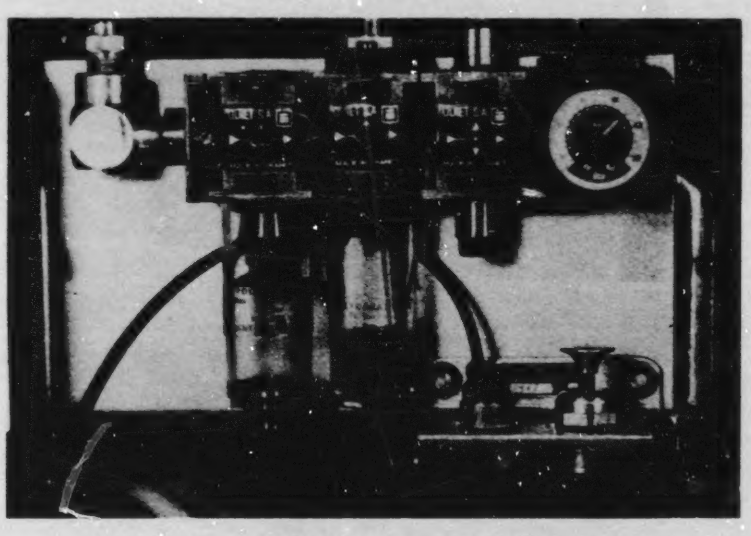
3. Replace tank lid

D. Check air line water separator oil level

1. Locate oil sight glass and check to see that oil is not below mark (Figure 16)

   (NOTE: Do not overfill.)

FIGURE 16



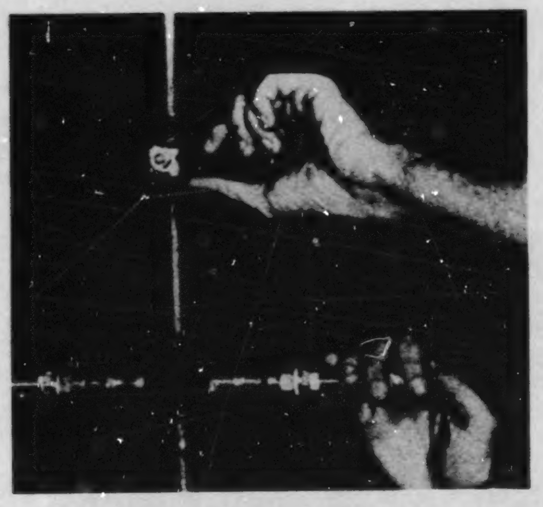
JOB SHEET #1

2. Add proper lubricant if required

   (NOTE: For the Baxter Vo-Tec 2000 Future Builder CNC Lathe, a light oil such as Mobil DTE Light [DTE24] should be used.)

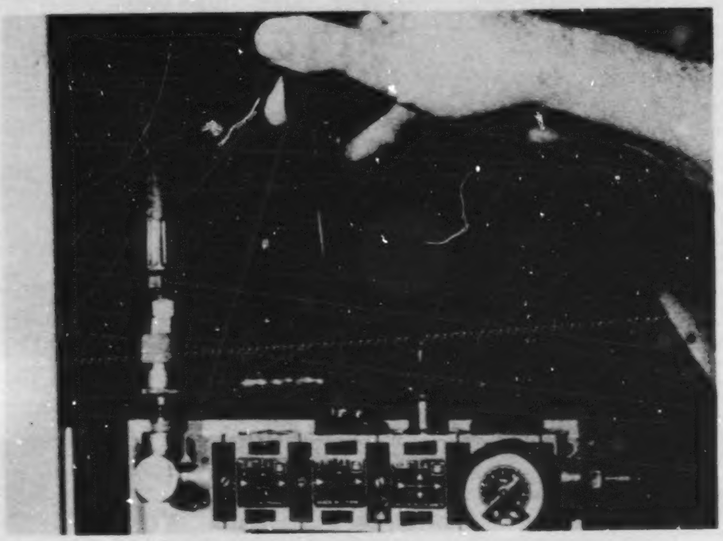
   a. Shut off air pressure (Figure 17)

FIGURE 17



   b. Remove brass filler plug on top of tank (Figure 18)

FIGURE 18



JOB SHEET #1

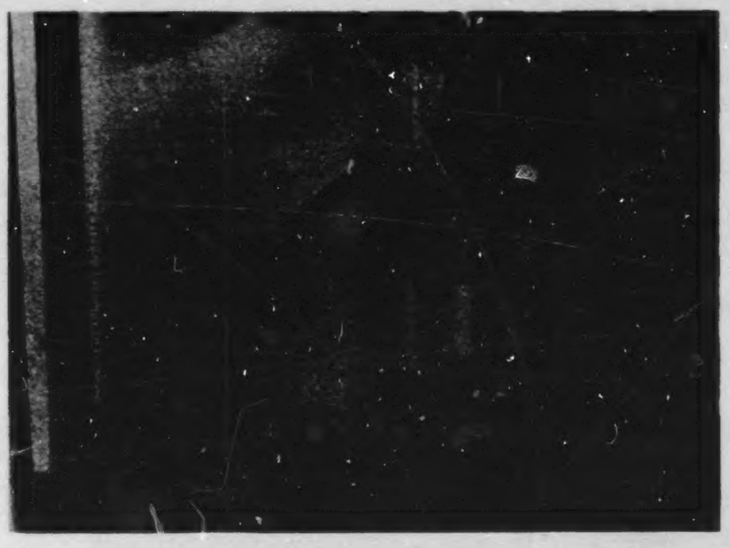
c. Add oil slowly until level in sight glass rises to mark

d. Replace filler cap

E. Drain air line water separator

1. Check for water in separator bowl (Figure 19)

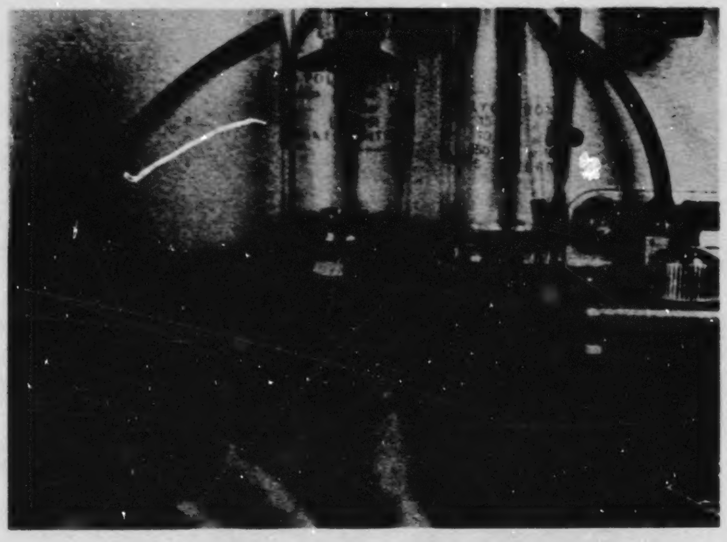
FIGURE 19



JOB SHEET #1

2. If water is present, shut off air pressure if not done previously and empty bowl by depressing stem in bottom of bowl (Figure 20)

FIGURE 20



3. Hold valve stem until all water has been discharged from the bowl

4. Release valve stem and check to see that valve stem has properly seated

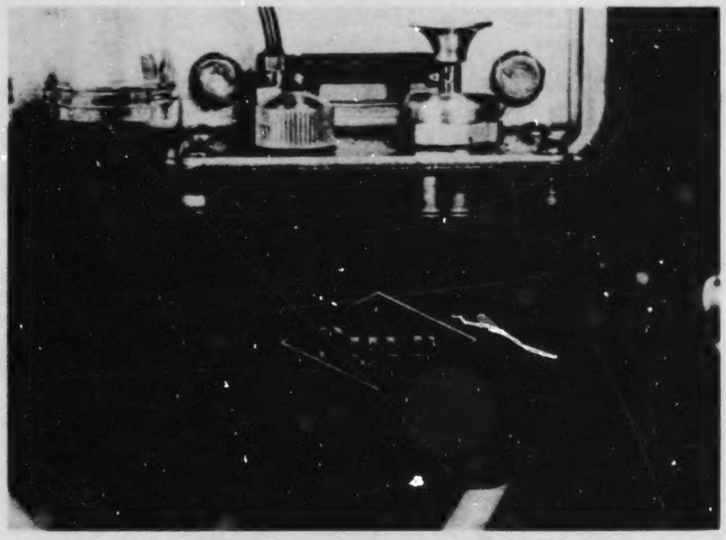
5. Turn on air pressure and adjust to 80-90 psi

JOB SHEET #1

F. Check way and ball lube reservoir

1. Locate way and ball lube bowl and check lubricant level (Figure 21)

FIGURE 21



2. Add way oil if level is below mark

(NOTE: Use appropriate way oil, such as Vactra #2. Do not overfill.)

G. Clean away excess lubricant or coolant from machine and area

H. Check lubricant lines and connections for leaks; report any leaks to your instructor

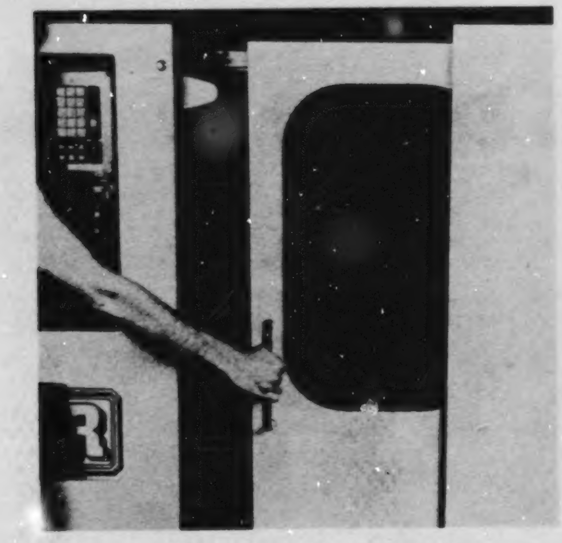
I. Check air line connections for leaks; tighten leaking connections as required and report leaks in lines to instructor

J. Replace left side panels

JOB SHEET #1

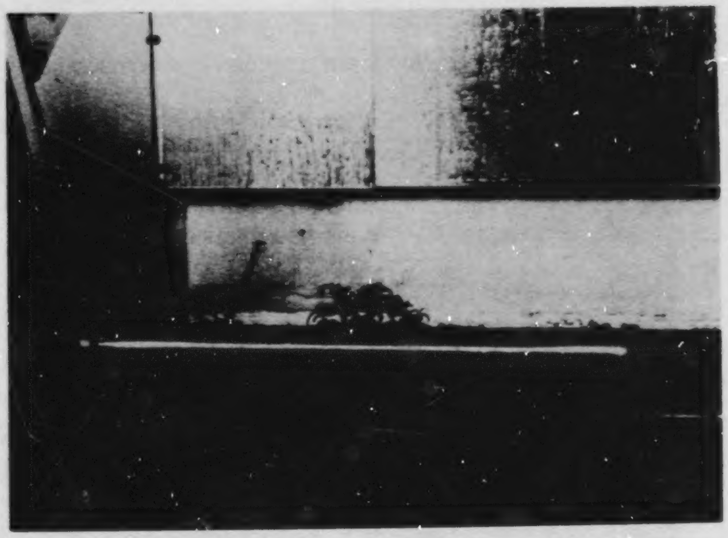
K. Open front safety guard door. (Figure 22)

FIGURE 22



L. Clean chips from machine and chip pan (Figure 23)

FIGURE 23

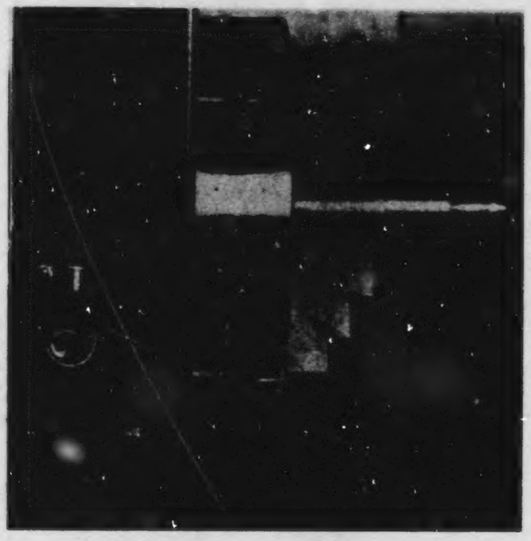


JOB SHEET #1

M. Check spindle oil

1. Locate oil gauge sight glass and check to see that oil is not below mark (Figure 24)

FIGURE 24



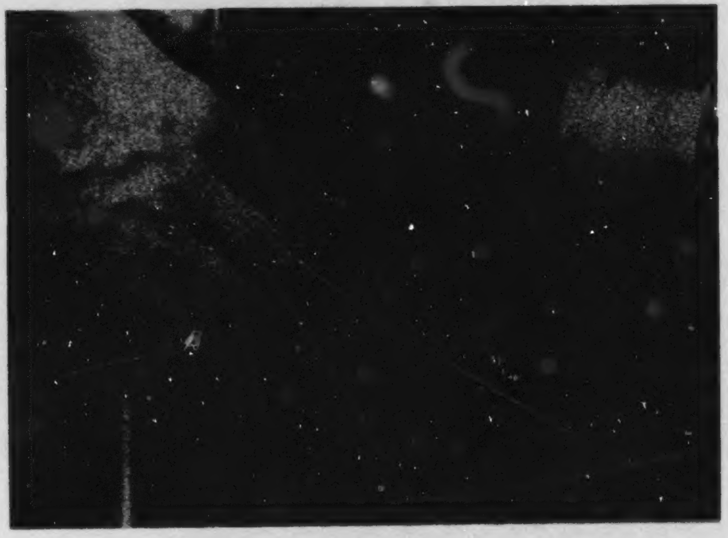
JOB SHEET #1

2. Lift hinged cap and add proper oil if necessary (Figure 25)

   (CAUTION: Be careful to avoid getting machining chips and other debris in reservoir. Always wipe area around cap clean before adding oil.)

   (NOTE: The spindle on the Baxter Vo-Tec 2000 Future Builder CNC Lathe uses a light oil such as Mobil DTE Light [DTE24].)

FIGURE 25

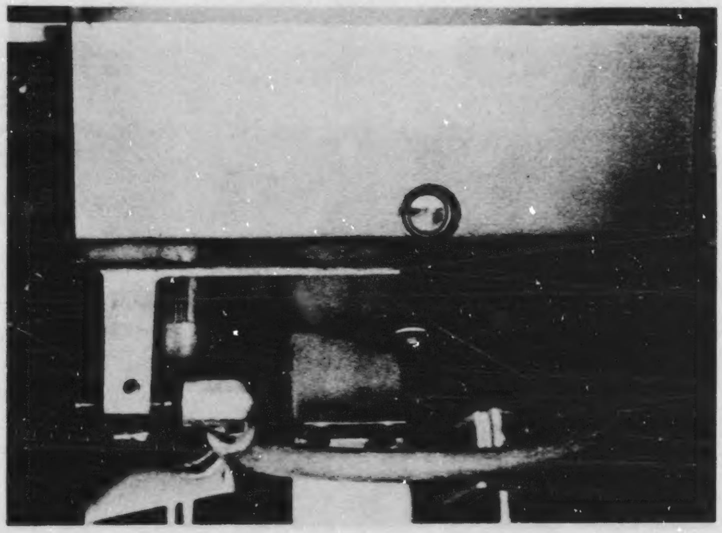


JOB SHEET #1

L. Check turret oil

1. Locate oil gauge sight glass and check to see that oil is not below mark (Figure 26)

FIGURE 26

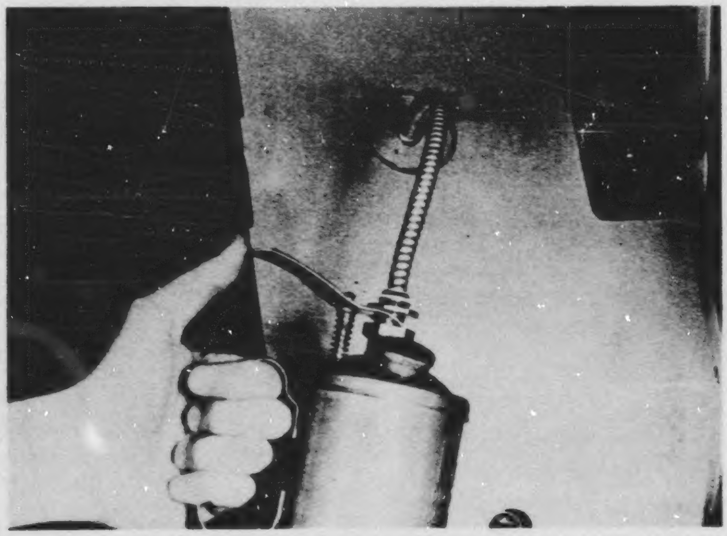


JOB SHEET #1

2. Add proper oil if necessary (Figure 27)

(NOTE: The turret on the Baxter Vo-Tec 2000 Future Builder CNC Lathe uses light oil such as Mobil DTE Light [DTE24].)

FIGURE 27



O. Clean excess oil from machine and area

P. Check lubricant lines and connections for leaks; report any leaks to your instructor

Q. Check air line connections for leaks; tighten leaking connections as required and report any other air leaks to instructor

R. Wipe slide ways with clean cloth

(NOTE: Other inspection items may be required for different machines. For example, some CNC lathes use air filters which must be inspected, cleaned, and replaced periodically. Become familiar with the machine you are using and refer to the manuals for specific instructions on care and maintenance for that particular machine; never assume that all machines require the same type of inspection and preventive maintenance.)

PERFORM PREVENTIVE MAINTENANCE
UNIT I

TEST

NAME ______________________________ SCORE ______________

1. Match terms associated with preventive maintenance to their correct definitions. Write the correct numbers in the blanks.

______a. Amount of clearance between ball screw and ball nut

______b. Device to remove water from the air lines used in the system

______c. Protective devices and covers placed around various parts of the machine to protect the user or to prevent accidental contact with switches and other parts

______d. Mechanical device used to transport chips from the machine and into a storage bin

______e. Switch used to remove all power to the machine

______f. Device used to read a numerical control (NC) tape in order to feed the tape information into the control unit or to operate machine directly from NC tapes

______g. Display screen used to provide user with information from the control unit

______h. Computerized portion of CNC machine including the computer memory and input and output devices

______i. Precisely ground rods or rails on which the turret and saddle ride

______j. Large threaded shaft that connects the servomotors to the saddle to allow motion of the X and Z axes

______k. Electric motors that allow extremely precise movements of the X and Z axes

______l. Switch that can be depressed to stop all machine functions immediately

______m. Mixture of water and chemicals used to provide cooling and lubrication during machining

1. Emergency stop
2. Ball screw
3. Slide ways
4. Backlash
5. Safety guards
6. Control unit
7. Coolant
8. Main disconnect switch
9. Servomotors
10. Air line water separator
11. Cathode ray tube
12. Chip conveyor
13. Tape reader

TEST

2. Select from a list facts concerning numerical control. Write an "X" in the blank beside each correct fact.

______a. Came into use in late 1970s

______b. Uses a code of numbers and letters to control machine operations

______c. Allows consistent repetition of an operation

______d. Allows complete part production without involvement of operator

______e. Reduces production time

______f. Reduces setup time substantially

______g. Can be used with a computer to provide greater flexibility and improved accuracy

3. Match jobs in shops using CNC lathes to their major responsibilities. Write the number of the job listed on the right beside its correct responsibilities.

______a. Responsible for performing routine maintenance inspection and powering up of the machine in preparation for production

______b. Responsible for interpreting work orders and setup sheets in order to load programs and set up tooling required for a specific production operation; may be required to perform inspections and power up machine

______c. Responsible for operating machines and making necessary inspections and adjustments during the production process; may be required to power up and set up machine

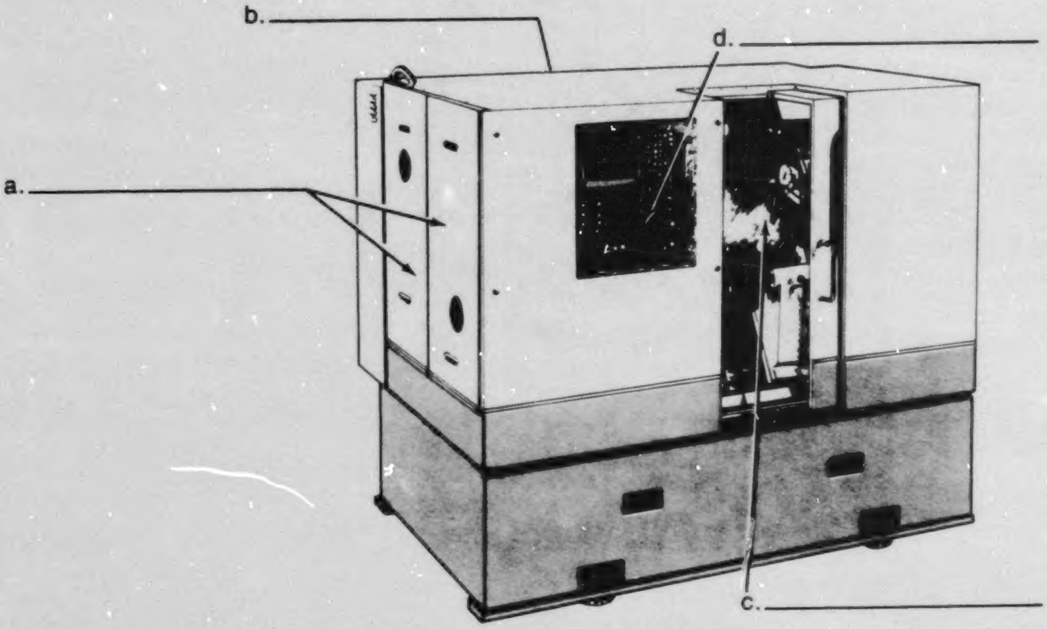
______d. Responsible for writing programs to be used in CNC lathe computers for part production

______e. Responsible for performing all tasks associated with CNC turning

1. CNC turning programmer
2. CNC lathe set-up person
3. CNC turning technician
4. CNC lathe operator
5. CNC lathe start-up person

TEST

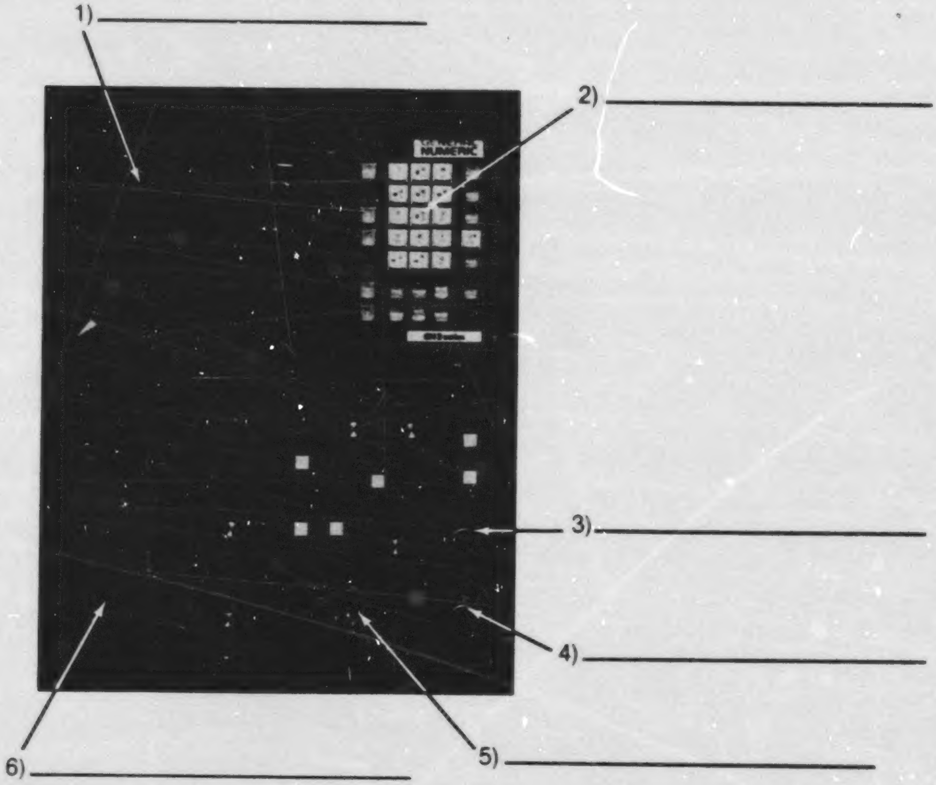
4. Label work areas of the Baxter Vo-Tec 2000 Future Builder CNC Lathe. Write the correct answers in the blanks.



TEST

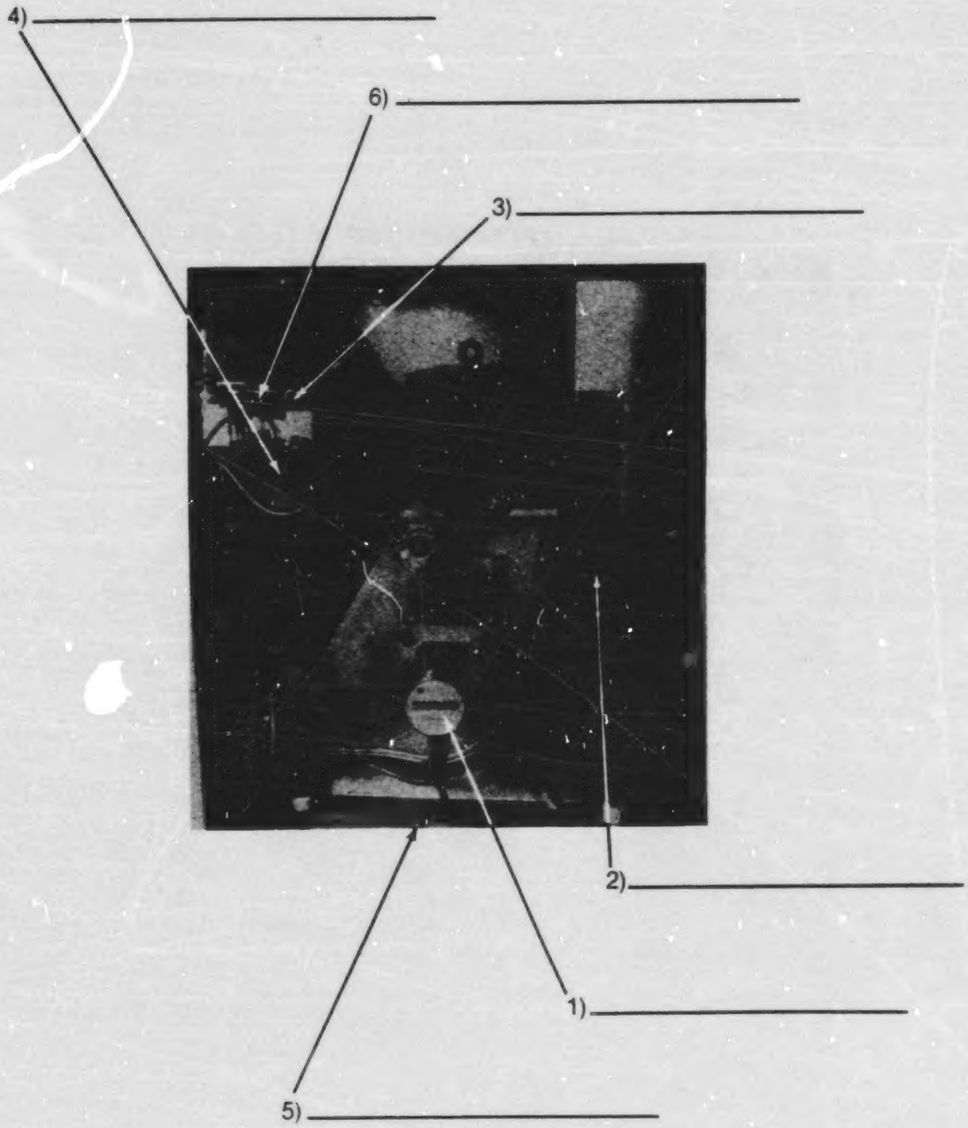
5. Label major parts of the Baxter Vo-Tec 2000 Future Builder CNC Lathe. Write the correct answers in the blanks.

   a. Control unit



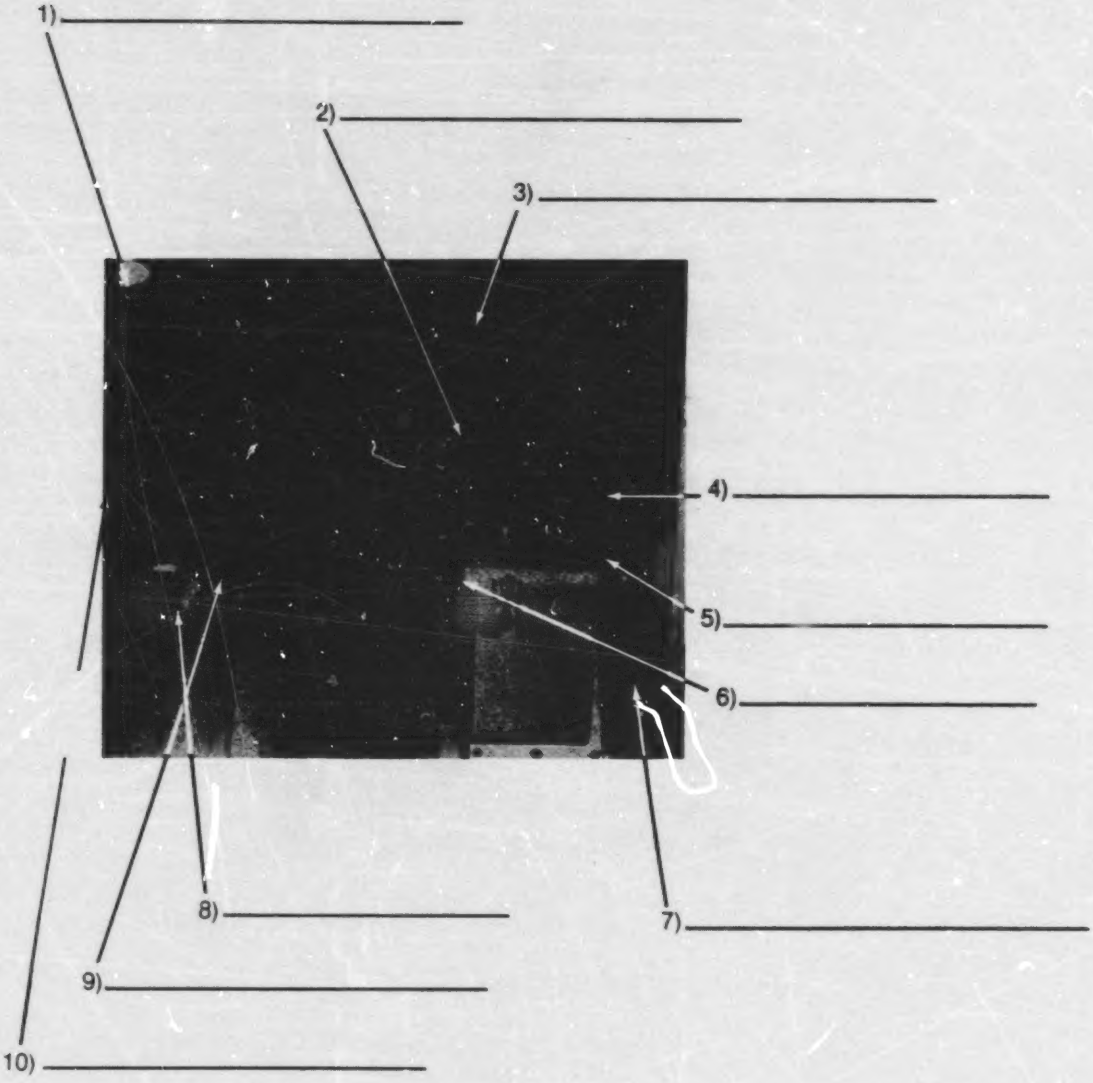
TEST

b. Left side panels



TEST

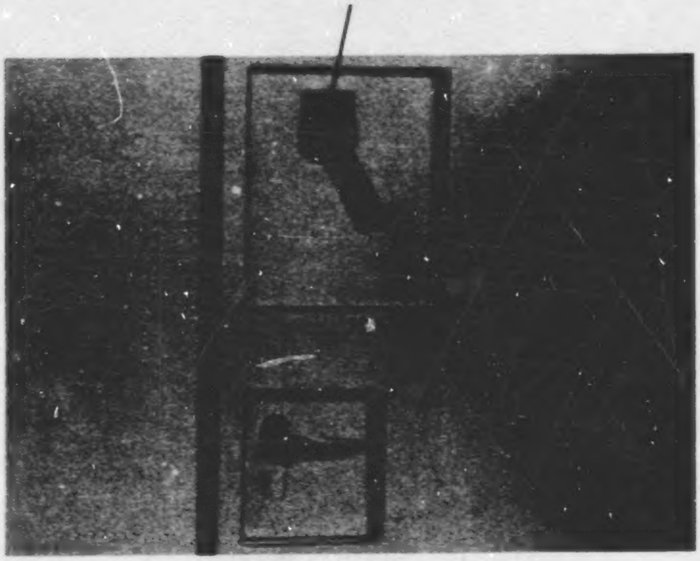
c. Work envelope


1)
2)
3)
4)
5)
6)
7)
8)
9)
10)

TEST

d. Rear panel

1) ______________________



6. Select from a list facts concerning the Cartesian coordinate system. In each list below, write an "X" beside each correct fact.

a. Cartesian coordinate axes

_____1) The X axis is a horizontal line running to the viewer's left and right in establishing a set of Cartesian coordinates

_____2) The Y axis is a horizontal line running toward and away from the viewer and intersecting the X axis at a right angle in establishing a set of Cartesian coordinates

_____3) The Z axis is a vertical line intersecting the X and Y axes at a right angle in establishing a set of Cartesian coordinates

b. Cartesian coordinate planes

_____1) All the lines that can be made parallel to a given axis and intersecting one other axis at right angles form a plane

_____2) There are two planes for each axis

_____3) There is one plane for each axis

TEST

c. Cartesian coordinate points

______1) The intersection of the three axes is considered the zero point in the Cartesian coordinate system

______2) Most but not all of the points along the axes can be labeled

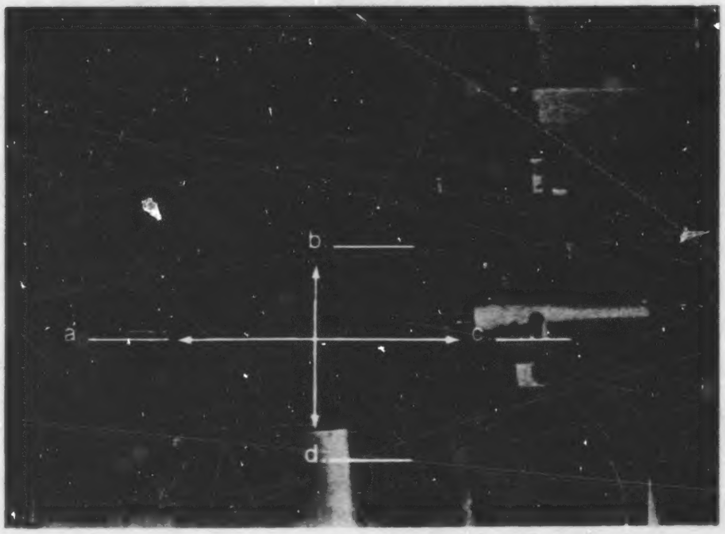
______3) Points to the left of the zero point on the X axis are positive; points to the right are negative

______4) Points on the side of zero away from the viewer on the Y axis are positive; points on the same side of zero as the viewer are negative

______5) Points below the zero point on the Z axis are positive; points above zero are negative

______6) Any point can be labeled using the X, Y, and Z values for that point

7. Label the axes for a CNC lathe. Write in the axis label and sign for each end of the two axes shown in the photograph below.



TEST

8. Match types of lubricants used in lathes to their correct descriptions. Write the correct numbers in the blanks.

_____a. Light weight oil used in hydraulic system to power spindle and other components

_____b. Light to medium weight oil used to lubricate moving machine parts such as the headstock and spindle

_____c. Medium weight oil used to lubricate the slide ways

1. Way oil
2. Hydraulic oil
3. Machine oil

(NOTE: Test questions 9 through 11 list the assignment sheets and job sheet. They are an important part of this test. If they have not been completed, check with your instructor.)

9. Label coordinate points.

10. Determine required lubricants and coolants.

11. Demonstrate the ability to perform routine inspection and maintenance.

PERFORM PREVENTIVE MAINTENANCE
UNIT I

ANSWERS TO TEST

1. a. 4 h. 6
   b. 10 i. 3
   c. 5 j. 2
   d. 12 k. 9
   e. 8 l. 1
   f. 13 m. 7
   g. 11

2. b, c, e, g

3. a. 5 d. 1
   b. 2 e. 3
   c. 4

4. a. Left side panels
   b. Rear panel
   c. Work envelope
   d. Control unit

5. a. 1) Cathode ray tube (CRT)
   2) Keypad
   3) Feed hold button
   4) E-Stop button
   5) Machine enable key switch
   6) Tape reader/punch port

ANSWERS TO TEST

b. 1) Spindle drive
   2) Z-axis servomotor
   3) Air pressure gauge
   4) Way lube reservoir
   5) Coolant tank
   6) Air line water separator

c. 1) Work light
   2) Turret
   3) Tool blocks
   4) X-axis ball screw
   5) X-axis servomotor
   6) Tail stock
   7) Z-axis ball screw
   8) Chuck
   9) Top jaws
   10) Door safety interlock switch

d. 1) Main disconnect switch

6. a. 1, 2, 3
   b. 1, 3
   c. 1, 4, 6

ANSWERS TO TEST

7. a. -Z
   b. +X
   c. +Z
   d. -X

8. a. 2
   b. 3
   c. 1

9. Evaluated to the satisfaction of the instructor

10. Evaluated to the satisfaction of the instructor

11. Performance skill evaluated to the satisfaction of the instructor

POWER UP MACHINE AND CONTROL
UNIT II

UNIT OBJECTIVE

After completing this unit, the student should be able to bring the machine from an inactive to an active mode and return it to an inactive mode. The student will show this knowledge by completing Assignment Sheet #1 and the unit test with a minimum score of 85 percent, Assignment Sheet #2 with a minimum score of 100 percent, and the job sheets accurately and completely in no more than 20 minutes each.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with machine and control power-up to their correct definitions.
2. Identify controls and indicators used to power up, check, and shut down the machine.
3. Match controls and indicators used to power up, check, and shut down the machine to their correct functions.
4. State functions of mode select switch positions used to power up, check, and shut down the machine.
5. Describe the types of programming used in a CNC lathe.
6. Match letter addresses to their correct meanings.
7. Match selected G codes to their correct functions.
8. Match selected M codes to their correct functions.
9. Select from a list types of CRT displays.
10. State meanings of status display codes.
11. Match alarm codes to their correct descriptions.
12. Complete statements about the operation of the joystick.
13. Describe the purposes of emergency stops and power switches.
14. Complete a CNC turning safety test.
15. Troubleshoot alarm indications during power up.

OBJECTIVE SHEET

16. Demonstrate the ability to
    - a. Power up, check, and shut down a CNC lathe.
    - b. Perform X axis and Z axis accuracy checks.

POWER UP MACHINE AND CONTROL
UNIT II

INSTRUCTIONAL OVERVIEW

I. Unit contents

  A. Objective sheet

  B. instructional overview (instructor copy)

  C. Instructional supplements (instructor copy)

  D. Information sheet

  E. Assignment sheets

    1. Assignment Sheet #1 — Troubleshoot Alarm Indications During Power-Up

    2. Assignment Sheet #2 — Complete CNC Turning Safety Test

  F. Answers to assignment sheets (instructor copy)

  G. Job sheets

    1. Job Sheet #1 — Power Up, Check, and Shut Down a CNC Lathe

    2. Job Sheet #2 — Perform X Axis and Z Axis Accuracy Checks

  H. Test

  I. Answers to test (instructor copy)

II. Suggested activities

  A. Review unit of instruction and plan method of presentation.

  B. Obtain materials necessary to supplement the unit.

  C. Make transparencies.

  D. Introduce unit to students.

  SUGGESTIONS:

  - Emphasize the importance of sequential power-up and shutdown with electronic equipment to preserve memory and proper functioning.
  - Show the students a complex program printout and explain how such data can be lost if procedures are not followed completely.

- Relate this unit to the previous unit by explaining that the start-up process is a continuation of the inspection procedure with the machine itself assisting with the inspection.

- Compare sequential power-up, checks, and shutdown to the procedure planning often required to machine a complex part in an efficient manner.

E. Provide students with unit of instruction.

F. Discuss unit and specific objectives; during your discussion, emphasize how the various objectives are important in light of your introduction to this unit.

G. Discuss information sheet.

1. Use Section I of the information sheet to help clarify the purpose of the objectives.

   SUGGESTIONS:

   - Show the students places they may encounter the terms in the operator's manual and on the machine itself.

   - Use the machine to demonstrate some of the terms such as *home, jog,* and various *modes.*

2. Use Section II of the information sheet to expand the students' knowledge of controls and indicators on the control unit.

   SUGGESTIONS:

   - Emphasize that the students are going through a building process in learning controls; other controls and indicators will be covered as they become important to the tasks in each area of training

   - Stress that the control unit has a separate operator's manual.

   - Compare the GN3 to control units on other machines in your shop.

3. Use Section III of the information sheet to explain the functions of controls and indicators.

   SUGGESTIONS:

   - Demonstrate the operation of switches and controls.

   - Emphasize the relationship between controls, indicators, CRT displays, and machine operations.

4. Use Section IV of the information sheet to discuss operation of the mode select switch; emphasize how the **JOG** and **MDI** positions affect control unit functioning and displays.

INSTRUCTIONAL OVERVIEW

5. Use Section V of the information sheet to discuss programming in the machine.

   SUGGESTIONS:

   - Expand the discussion by giving examples of the kinds of information included on the executive software, such as machine zero values, meanings of codes, responses to inputs, etc.
   - Demonstrate changes to the parts program, such as canceling U and W values, loading spindle speeds, inputting various codes, etc.; emphasize this as a means of changing machine functions.
   - Display various program devices such as tapes and discs.

6. Use Section VI of the information sheet to introduce students to letter addresses.

   SUGGESTIONS:

   - Relate letter addresses to the concept of a mailing *address* to which a *letter* is sent, emphasizing that letter addresses allow the operator to direct the machine to the part of the memory required for a particular function.
   - Demonstrate letter addresses on the machine.

7. Use Section VII of the information sheet to discuss G codes.

   SUGGESTIONS:

   - Emphasize that other G codes exist and will be discussed later in the course.
   - Demonstrate G codes on the machine, emphasizing the flexibility allowed through codes and the ease of making machining changes.

8. Use Section VII of the information sheet to discuss M codes.

   SUGGESTIONS:

   - Emphasize that other M codes exist and will be discussed later in the course.
   - Demonstrate M codes on the machine, emphasizing the flexibility allowed through codes and the ease of making changes.
   - Be sure that students understand how direction of rotation is determined.

9. Use Section IX of the information sheet to discuss CRT displays.

   SUGGESTIONS:

   - Demonstrate the various displays.
   - Allow students to practice changing display page to give them experience and to help them in learning the various displays.
   - Display various pages and ask students questions about the information presented.

   (NOTE: Emphasize information relevant to powering up and checking the machine. This exercise can be repeated later to allow students further practice as they learn more about the displays and machine operation.)

10. Use Section X of the information sheet to discuss status display codes and their meanings.

    SUGGESTIONS:

    - Emphasize the display codes in the information sheet and demonstrate them.
    - Display other codes, emphasizing that the students should be mainly concerned about those in the information sheet.

11. Use Section XI of the information sheet to discuss alarm codes.

    SUGGESTIONS:

    - Point out the safety aspects of using alarm codes.
    - Demonstrate the alarm codes on the machine.
    - Use Assignment Sheet #1 to reinforce the information on alarm codes and to work with the operator's manual.

12. Use Section XII of the information sheet to discuss operation of the joystick and to introduce the use of emergency stops and switches.

    SUGGESTIONS:

    - Demonstrate each mode of operation.
    - Allow students to practice using the joystick, emphasizing the need to learn how to monitor the machine movements, the tools, the part, and the CRT simultaneously; encourage students that such skills take practice to acquire.

INSTRUCTIONAL OVERVIEW

13. Use Section XIII of the information sheet to discuss emergency stops and power switches.

    SUGGESTIONS:

    - Point out the switches and stops on the machine.
    - Emphasize the importance of activating and deactivating the switches in proper sequence.
    - Discuss emergency shutdown and use the discussion as a lead-in to safety in general.

14. Prepare the students for work in the shop by reviewing safety procedures using Section XIV of the information sheet.

    SUGGESTIONS:

    - Demonstrate safety practices and emergency shutdown on the machine.
    - Point out the location of and demonstrate the use of safety equipment in your shop.
    - Require students to achieve a score of 100 percent on Assignment Sheet #2 before performing hands-on operation of the control unit or lathe.
    - Display safety posters in your shop, emphasizing special dangers associated with fast-response machinery such as that using computer controls.
    - Invite safety and health personnel to talk to the class on common shop injuries and first aid.
    - Offer some kind of award or special privilege to students who complete the course without injuries or safety violations.
    - Emphasize that safe operation of machine shop equipment is just as much a skill as other aspects of machining.

H. Demonstrate job sheets.

SUGGESTION: Show videotape presentations.

I. Allow students to practice job sheet procedures; remind them of the time limit for completing the jobs successfully.

J. Give test.

K. Reteach and retest if necessary.

POWER UP MACHINE AND CONTROL
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Power up — To bring the machine and control unit from a power-off condition to an operating state

B. Mode — Operating status of the machine or the control unit

(NOTE: A number of modes are possible with CNC equipment. The *inactive mode* is a power-off condition. Powering up the machine and control unit take the equipment from the *inactive mode* to the *active mode*. There are also specific modes for feed rates, spindle speeds, and other aspects of machine operation and control unit status.)

C. Code — A number, letter, or combination of numbers and letters used to place the machine or control unit into various modes; also used to inform operator of operating status of machine or control unit

D. Letter address — Letter used to designate the type of command addressed by a code

EXAMPLE: The letter address *F* designates codes for feed rates.

E. Control status — Current control unit mode of operation, including all codes that are presently active

F. Alarm code — Code used to notify operator that an unsafe or damaging situation exists or has been commanded; also used to notify operator of improper commands

G. Machine zero — Point along a given axis (X or Z) designated by the manufacturer for machine reference

(NOTE: The machine zero point is part of the nonprogrammable memory loaded by the manufacturer. The operator is able to select a *program zero* or *part zero point*, and this serves as the datum point for commands and for programming. For the Future Builder, machine zero is X 22.585 and Z 10.250.)

H. Machine home — Extreme limits of travel along axes

I. Home (Zero-return) — Command to move a given axis (X or Z) to its machine home position

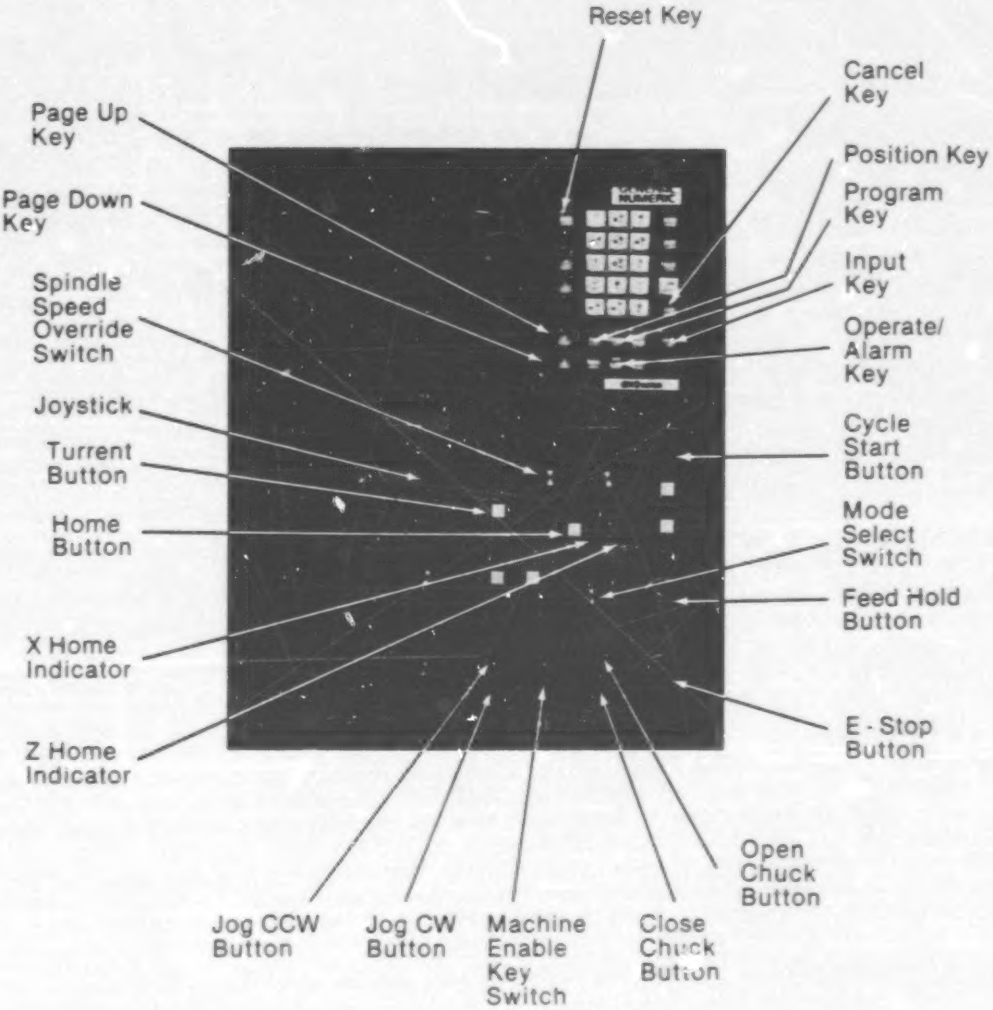
J. Jog — To manually move an axis or the spindle

K. Manual data input (MDI) — Process of loading information into the control using the keypad

INFORMATION SHEET

II. Controls and indicators used to power up, check, and shut down the machine (Figure 1)

FIGURE 1


Reset Key
Page Up Key
Cancel Key
Position Key
Page Down Key
Program Key
Spindle Speed Override Switch
Input Key
Operate/ Alarm Key
Joystick
Cycle Start Button
Turrent Button
Mode Select Switch
Home Button
Feed Hold Button
X Home Indicator
E - Stop Button
Z Home Indicator
Open Chuck Button
Jog CCW Button
Jog CW Button
Machine Enable Key Switch
Close Chuck Button

INFORMATION SHEET

III. Functions of controls and indicators used to power up, check, and shut down the machine

A. Reset key — Used to reset alarm indications and to cancel information input on the keypad prior to pressing the cycle start button

B. Cancel key — Used to cancel information input on the keypad prior to pressing the input key

C. Position key — Used to set CRT to display positions of the axes

D. Program key — Used to allow the operator access to the programmable portion of the control memory

E. Input key — Used to store information fed through the keypad

F. Operate/Alarm key — Used to check control status for valid alarms

G. Cycle start button — Used to begin sequence of operations input into control

H. Mode select switch — Used to set various operation modes for control, such as JOG and MDI

I. Feedhold button — Used to stop movement of axes

(NOTE: The FEEDHOLD button will not stop the spindle or coolant if operating.)

J. E-Stop button — Used to stop all movement of the machine, including spindle and coolant

K. Close chuck button — Used to close chuck jaws

L. Open chuck button — Used to open chuck jaws

M. Machine enable key switch — Used to provide power to or remove power from control unit

N. Jog CW button — Used to turn spindle clockwise for short intervals

O. Jog CCW button — Used to turn spindle counterclockwise for short intervals

P. Page up key — Used to change CRT display by moving forward through pages

Q. Page down key — Used to change CRT display by moving backwards through pages

INFORMATION SHEET

R. Spindle speed override switch — Used to allow operator to manually adjust percentage of programmed spindle speed to be used

EXAMPLES: If the programmed speed is 500 rpm and the spindle speed override switch is set at 100 percent, the spindle speed will be approximately 500 rpm; if the switch is set at 50 percent, the spindle will rotate at approximately 250 rpm.

S. Joystick — Used to make movements along X and Z axes

T. Turret button — Used to index turret one station forward without using program command

U. Home button — Used to prepare control for movement of the axes to the home positions

V. X home indicator — Used to show when X axis reaches home position by illumination of light

W. Z home indicator — Used to show when Z axis reaches home position by illumination of light

IV. Mode selection switch positions used to power up, check, and shut down the machine

A. MDI — Used to allow operator to input data by means of the keypad

B. Jog — Used to allow operator to jog the spindle with the jog CW and jog CCW buttons

V. Types of programming used in a CNC lathe

A. Executive software — Information stored in the control by the manufacturer that allows the machine to interpret codes and other functions; contains data that is not affected by operator-loaded information

B. Part program — Information loaded into the control by the operator through the keypad or other means for temporary use in specific production operations

VI. Letter addresses

(NOTE: CNC codes and addresses have been standardized throughout the industry. There may be, however, slight differences in the exact program functions of a particular code or address for each machine.)

A. F — Letter address for feed rate commands

INFORMATION SHEET

B. G — Letter address for commands that prepare the machine to make specific movements at specific rates or that causes specific functions; known as *preparatory functions*

C. M — Letter address for miscellaneous function commands

(NOTE: The primary use of M codes is to turn equipment on or off, such as starting the spindle or stopping coolant flow.)

D. N — Letter address for numbering sequences within a program

E. O — Letter address for numbering programs

F. S — Letter address for spindle speed commands

G. T — Letter address for tool and offset commands

(NOTE: The first two digits in a tool and offset command designate the tool number and the second two digits show the offset.)

VII. Selected G codes

A. G00 — Directs control to use rapid traverse mode

(NOTE: Rapid traverse for the Baxter Vo-Tec 2000 Future Builder CNC Lathe is at a rate of 200 inches per minute.)

B. G01 — Directs control unit to generate a straight line at the stored feed rate

C. G02 — Directs control unit to generate a clockwise circular motion at the stored feed rate

D. G03 — Directs control unit to generate a counterclockwise circular motion at the stored feed rate

E. G20 — Directs control unit to use inch system

(NOTE: With an active G20 code, all axis commands will be interpreted as inches. Measurements in inches are accurate to four decimal places.)

F. G21 — Directs control unit to use metric system

(NOTE: With an active G21 code, all axis commands will be interpreted as millimeters. Measurements in millimeters are accurate to three decimal places.)

INFORMATION SHEET

G. G96 — Directs control unit to invoke constant surface speed (CSS) mode for spindle

(NOTE: With an active G96 code, all S code commands are interpreted as surface feet per minute [sfpm].)

H. G97 — Directs control unit to invoke direct rpm for spindle

(NOTE: With an active G97 code, all S code commands will be interpreted as rpm.)

I. G98 — Directs control unit to invoke a per minute feed rate

(NOTE: With an active G98 code, all F code commands will be interpreted as inches per minute [ipm] or millimeters per minute, depending on measurement in program.)

J. G99 — Directs control unit to invoke a per revolution feed rate

(NOTE: With an active G99 code, all F code commands will be interpreted as inches per revolution [ipr] or millimeters per revolution, depending on measurement in program.)

VIII. Selected M codes

A. M03 — Directs control unit to start spindle in forward (CW) direction

(NOTE: On the Future Builder direction of rotation is determined with the operator facing the tailstock.)

B. M04 — Directs control unit to start spindle in reverse (CCW) direction

C. M05 — Directs control unit to stop spindle

D. M08 — Directs control unit to start coolant flow

E. M09 — Directs control unit to stop coolant flow

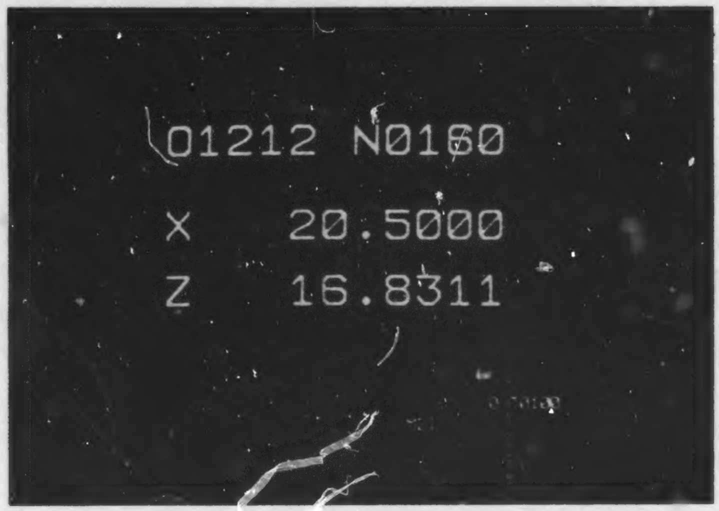
INFORMATION SHEET

IX. Types of CRT displays

A. Status display (Figure 2)

EXAMPLE:

FIGURE 2



```
O1212 N0160

X    20.5000
Z    16.8311
```

B. Input data display (Figure 3)

EXAMPLE:

FIGURE 3

INFORMATION SHEET

C. Program and sequence number displays (Figure 4)

EXAMPLE:

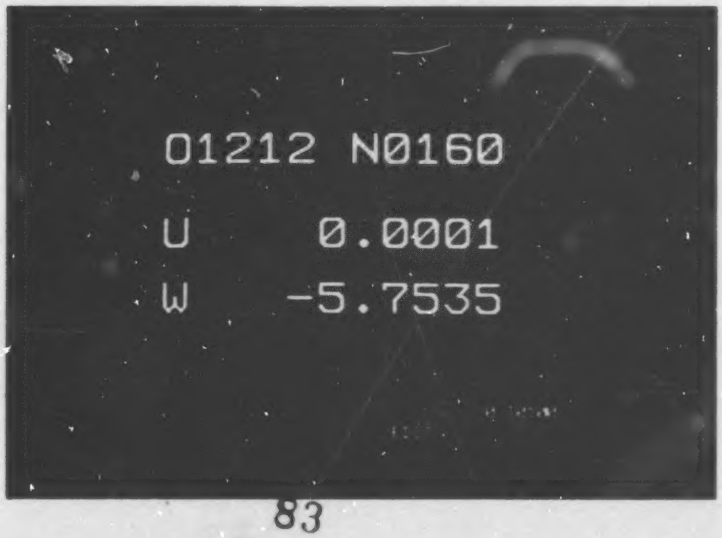
FIGURE 4

D. Preset position displays

1. Page 1 — Preset position of X and Z axes in relation to home position (Figure 5)

EXAMPLE:

FIGURE 5



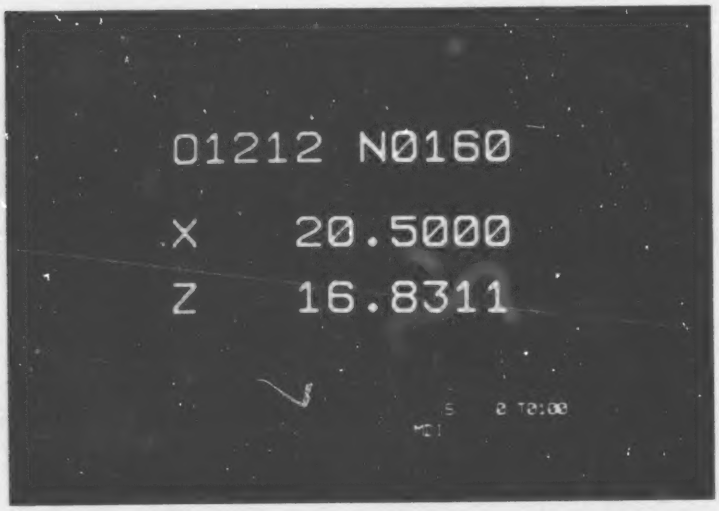
```
01212 N0160
U     0.0001
W    -5.7535
```

INFORMATION SHEET

2. Page 2 — Preset position in G50 coordinates (Figure 6)

EXAMPLE:

FIGURE 6



```
O1212 N0160

X    20.5000
Z    16.8311

                 S    0 T0100
               MDI
```

3. Page 3 — Preset position in relative coordinates (Page 1), absolute coordinates (Page 2), machine coordinates (distance from machine zero point); also shows distance left for each axis to travel in the remaining part of the programmed operation (Figure 7)

EXAMPLE:

FIGURE 7

```
                         0 T0100
                   MDI
```

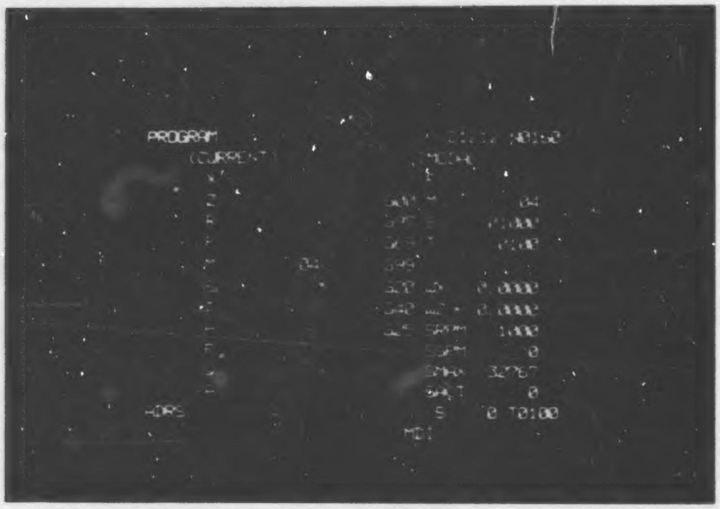
INFORMATION SHEET

E. Command data displays

1. Page 1 — Commands and modes stored in portion of program (Figure 8)

   EXAMPLE:

   FIGURE 8



2. Page 2 — Command data being input with MDI (Figure 9)

   EXAMPLE:

   FIGURE 9

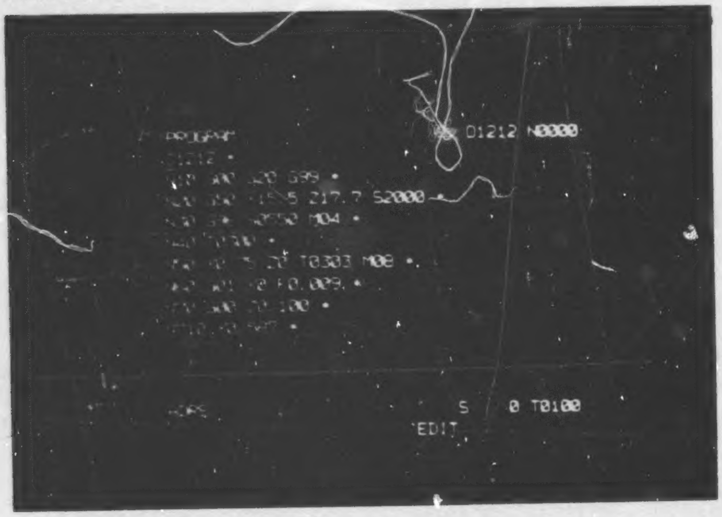
INFORMATION SHEET

F. Program data displays

1. Page 1 — Program data for block of program currently in use with mode selection switch in EDIT or AUTO (Figure 10)

   EXAMPLE:

   FIGURE 10


PROGRAM
O1212 N0000
S 0 T0100
EDIT

2. Page 2 — Program data for block of program being executed and the block about to be executed with mode selection switch in any position other than EDIT or AUTO (Figure 11)

   EXAMPLE:

   FIGURE 11

PROGRAM
O1212 N0160
CURRENT
NEXT

INFORMATION SHEET

G. Offset data displays — Amount of offset for an axis at a tool position (Figure 12)

EXAMPLE:

FIGURE 12

X. Status displays codes and their meanings

A. NOT READY — Indicates that machine and control are not ready for operation during power up

B. ALM — Indicates that an alarm condition exists

C. EDIT — Indicates that control unit is performing edits specified by operator

D. SRCH — Indicates that the control is searching for a sequence number

(NOTE: Other display codes are used, but these are the most frequently used to provide the operator with status information important in monitoring machine operations. See the machine manuals for additional status display codes.)

XI. Selected alarm codes

A. +X — Indicates that X axis has exceeded maximum travel distance in the + direction

INFORMATION SHEET

B. −X — Indicates that X axis has exceeded maximum travel distance in the − direction

C. +Z — Indicates that Z axis has exceeded maximum travel distance in the + direction

D. −Z — Indicates that Z axis has exceeded maximum travel distance in the − direction

E. 01 — Indicates that too much force has been applied along either the X or Z axis

(NOTE: The use of too much force is known as an *overload.*)

F. 15 — Indicates an excess drift error on the X axis

(NOTE: An excess drift error occurs when an actual machine position differs from what is in the control unit

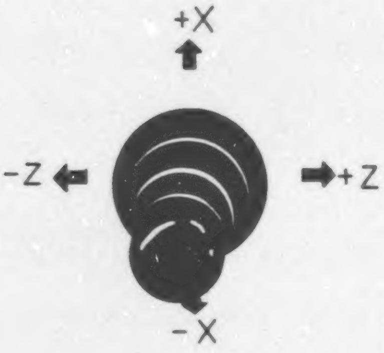
G. 25 — Indicates an excess drift error on the Z axis

XII. Operation of the joystick

A. Shifts in one of four directions to move axes (Figure 13)

EXAMPLE:

FIGURE 13



INFORMATION SHEET

B. With mode select switch in STEP, axis moves at increment setting each time joystick is moved to shifted position

C. With mode select switch in JOG, axis moves continuously until it reaches limits as long as joystick is held in shifted position

D. With HOME light set, axis moves to home point and stops when joystick is shifted to + position and held

XIII. Emergency stops and power switches

A. Emergency stop push button

1. Stops all machine functions immediately

2. Locks in place when depressed; must be rotated clockwise to release

B. Main disconnect switch — Must be in the *ON* position to supply power to machine and control unit

C. Machine enable key switch — Must be in the *ON* position for machine operation in any mode

XIV. CNC turning safety

A. Wear approved safety glasses with side shields

B. Remove watches, rings, and similar jewelry before operating machinery

C. Wear close-fitting clothes with shirttail tucked into pants; button long sleeves or roll up past elbow

D. Tie up long hair

E. Conduct yourself in a safe and responsible manner

(NOTE: Horseplay is strictly prohibited in shop area.)

F. Stop lathe when measuring, adjusting, cleaning, or oiling

G. Never use hands to try to stop lathe spindle or chuck, to grab chips, or to remove hot work from work-holding device

H. Never use rags around revolving or moving parts

I. Never operate a machine with guards removed

INFORMATION SHEET

J. Keep floor clean and free of chips and oil to eliminate slipping and tripping hazards

K. Always check work-holding devices to make sure that they are mounted securely

L. Never leave tools lying on machine

M. Always clean chucks before mounting on spindle; never set chucks directly on the ways

N. Rotate large or oddly shaped parts that are chucked a complete revolution by hand to make sure jaws and work clear the ways and carriage

O. Remove all sharp edges and burrs from work

P. Read and follow all the operating manuals applicable to the machine and control unit

Q. Place the mode selector in the *MDI* position and the machine enable key switch to *OFF* if the machine is to be left unattended for any period of time

R. Do not attempt any electrical or electronic repairs to the machine

S. Never operate a machine on which a malfunction has occurred; get the problem fixed before using the machine

T. Do not alter the machine's design or functioning in any way

U. Close the safety door before operating the machine in the *AUTO* mode of operation

POWER UP MACHINE AND CONTROL
UNIT II

ASSIGNMENT SHEET #1 — TROUBLESHOOT ALARM INDICATIONS DURING POWER-UP

NAME ______________________________ SCORE ____________

The control unit on your CNC lathe is designed to work with you as a helpful tool in your turning operations. For that reason, the system uses a number of alarms and displays to inform you of machine and control status and to warn you of incorrect or dangerous conditions. Use the information sheet and the operator's manuals for your CNC lathe system to answer the following questions about alarm indications during power-up.

A. While checking the control status during power-up, a 15 alarm is displayed when you depress the *OPR/ALM* button.

1. What should you do? ______________________________

____

2. If the alarm is still displayed after taking the action you described above, what is your next step? ______________________________

____

B. While homing the axes during power-up, a −X alarm code is displayed when you shift the joystick in the −X direction.

1. What does this alarm mean? ______________________________

____

2. What action must you take to reset the alarm? ______________________________

____

C. While homing the axes during power-up, an alarm code 01 appears.

1. What does this alarm mean? ______________________________

____

2. What must you do to correct the condition? ______________________________

____

POWER UP MACHINE AND CONTROL
UNIT II

ASSIGNMENT SHEET #2 — COMPLETE A CNC TURNING SAFETY TEST

NAME ______________________________ SCORE ____________

Safety is as much a part of proper machine operation as knowing the controls and their functions. There are general safety rules for all shops, and there are those that are particular to certain types of machining and to specific machines. To demonstrate your understanding of CNC lathe safety requirements, you must achieve a score of 100 percent on this test. Below are listed some key words and phrases from safety rules for the CNC lathe. In the space provided, state the safety rule in your own words.

A. Eye protection — ______________________________

____

B. Watches, rings, and similar jewelry — ______________________________

____

C. Clothing — ______________________________

____

D. Conduct — ______________________________

____

E. Measuring, adjusting, cleaning, or oiling — ______________________________

____

F. Hands — ______________________________

____

G. Rags — ______________________________

____

H. Guards — ______________________________

____

I. Floor — ______________________________

____

ASSIGNMENT SHEET #2

J. Work-holding devices — ____

____

K. Tools lying on machine — ____

____

L. Cleaning chuck — ____

____

M. Large or oddly shaped parts that are to be chucked — ____________________

____

N. Sharp edges and burrs — ____

____

O. Operating manuals — ____

____

P. Leaving machine unattended — ____

____

Q. Electrical and electronic repairs — ____

____

R. Machine with malfunction — ____

____

S. Altering the machine's design or function — ____________________

____

T. Safety door — ____

____

U. Long hair — ____

____

POWER UP MACHINE AND CONTROL
UNIT II

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

A. 1. *RESET* key

   2. Refer to operator's manual for proper action

B. 1. Indicates that X axis has exceeded maximum travel distance in the – direction

   2. Move X axis in +X direction and press *RESET* key

C. 1. Indicates that too much force has been applied along either the X or Z axis

   2. Home axes and press *RESET* key

Assignment Sheet #2

A. Wear approved safety glasses with side shields

B. Remove watches, rings, and similar jewelry before operating machinery

C. Wear close-fitting clothes with shirttail tucked into pants; button long sleeves or roll up past elbow

D. Conduct yourself in a safe and responsible manner

E. Stop lathe when measuring, adjusting, cleaning, or oiling

F. Never use hands to try to stop lathe spindle or chuck, to grab chips, or to remove hot work from work-holding device

G. Never use rags around revolving or moving parts

H. Never operate a machine with guards removed

I. Keep floor clean and free of chips and oil to eliminate slipping and tripping hazards

J. Always check work-holding devices to make sure that they are mounted securely

K. Never leave tools lying on machine

ANSWERS TO ASSIGNMENT SHEETS

L. Always clean chucks before mounting on spindle; never set chucks directly on the ways

M. Rotate large or oddly shaped parts that are chucked a complete revolution by hand to make sure jaws and work clear the ways and carriage

N. Remove all sharp edges and burrs from work

O. Read and follow all the operating manuals applicable to the machine and control unit

P. Place the mode selector in the *MDI* position and the machine enable key switch to *OFF* if the machine is to be left unattended for any period of time

Q. Do not attempt any electrical or electronic repairs to the machine

R. Never operate a machine on which a malfunction has occurred; get the problem fixed before using the machine

S. Do not alter the machine's design or functioning in any way

T. Close the safety door before operating the machine in the *AUTO* mode of operation

U. Tie up long hair

POWER UP MACHINE AND CONTROL
UNIT II

JOB SHEET #1 — POWER UP, CHECK, AND SHUT DOWN A CNC LATHE

I. Equipment and materials

   A. CNC lathe

   B. Operator's manual

   C. Shop towels

II. Procedure

   A. Perform routine inspection and maintenance as required

   B. Power up machine and control

      1. Turn main power disconnect switch to *ON*

      2. Check emergency stop and feed hold buttons; release if necessary

         (NOTE: Push buttons in and turn counterclockwise to release.)

      3. Turn machine enable key switch to *ON*

      4. Wait for *NOT READY* message to go out

   C. Home all axes

      1. Page to U and W display

      2. Set mode select switch to *JOG*

      3. Press the yellow *HOME* button

         (NOTE: Once pressed, the *HOME* button will illuminate steadily.)

      4. Move joystick to the *X+* position and hold it there until the green *X HOME* light comes on; return joystick to neutral

      5. Move joystick to the *Z+* position and hold it there until the green *Z HOME* light comes on; return joystick to neutral

         (NOTE: The yellow *HOME* button light should go out.)

      6. Press *U* key

      7. Press *CAN* key

JOB SHEET #1

8. Press *W* key
9. Press *CAN* key

D. Check control status

1. Press *OPR/ALM* button
    a. If an alarm appears, press the *RESET* key
    b. If the alarm is still displayed, refer to the operator's manual for proper action
    c. Attempt procedure to correct alarm

       (NOTE: Press *RESET* key after each corrective action.)
    d. If alarm is still displayed, notify instructor
2. Check to see that *X HOME* and *Z HOME* lights are lit
3. Check that machine enable key switch is *ON*

E. Check air pressure if chuck is to be used

1. Check to see that chuck and jaws are securely fastened
2. Check pressure gauge through sight hole in left side panel

   (NOTE: Air pressure reading should be between 80 and 90 pounds per square inch.)
3. Notify instructor if incorrect reading is found

F. Start and check spindle using MDI

1. Set mode select switch to *MDI*
2. Press gray *PRGRM* key
3. Press either *PAGE* key until MDI display appears

   (NOTE: The displays are identified by an abbreviation in parentheses in the upper left corner of the screen.)
4. Close chuck jaws
5. Close guard door

JOB SHEET #1

6. Set spindle speed override (SSO) to *100%*

7. Key in *G97* and press the *INPUT* key

8. Key in *S500* and press the *INPUT* key

9. Key in *M03* and press the *INPUT* key

   (NOTE: The control is now set for the spindle to rotate at 500 rpm in the forward direction.)

10. Press the green *CYCLE START* button and check for proper rotation

    (NOTE: Check CRT for spindle speed. Speed should be within ±10 percent of programmed speed.)

11. Key in *M05* and press the *INPUT* key

12. Press the *CYCLE START* button and check to see that spindle stops

    (NOTE: It is not necessary to stop the spindle prior to changing direction of rotation on the Baxter Future Builder. However, some machines require the use of an M05 code, and the procedure is a good practice to follow.)

13. Key in *M04* and press the *INPUT* button

14. Press the *CYCLE START* button and check to see that spindle rotates in reverse direction

15. Key in *M05* and press the *INPUT* key

16. Press the *CYCLE START* button and check to see that spindle stops

G. Jog spindle in manual mode

   1. Set mode select switch to *JOG*

   2. Press the *JOG CCW* button and hold it

      (NOTE: The spindle should rotate in the reverse direction at approximately 200 rpm until the button is released.)

   3. Release *JOG CCW* button

   4. Press the *JOG CW* button

      (NOTE: The spindle should turn in the forward direction at approximately 200 rpm.)

5. Release the *JOG CW* button

H. Index turret using MDI

1. Set mode select switch to *MDI*
2. Check to see that all tooling has enough clearance for turret to rotate

   (CAUTION: Maximum extension from qualifying pin out is 6" on the Baxter Future Builder.)
3. Press the gray *PRGRM* key
4. Press either *PAGE* key until MDI screen appears
5. Key in *T0100* and press the *INPUT* key
6. Press the *CYCLE START* button and note that the turret indexes to the number one position

   (NOTE: The turret will not index in *MDI* unless the safety door is closed.)
7. Key in T0300 and press the *INPUT* key
8. Press the *CYCLE START* button and note that the turret indexes to the number three position

I. Index turret using manual mode

1. Set mode select switch to *JOG*
2. Check to see that all tooling has enough clearance for turret to rotate
3. Press *TURRET* button and note that turret rotates one position

   (NOTE: The turret will rotate one station each time the *TURRET* button is depressed.)

J. Shut down machine

1. Home all axes

   (NOTE: It is a good idea to home axes before turning off power to avoid possible damage during next startup.)
2. Press and lock emergency stop and feed hold buttons
3. Turn machine enable key switch to *OFF*
4. Turn main disconnect switch to *OFF*

POWER UP MACHINE AND CONTROL
UNIT II

JOB SHEET #2 — PERFORM X AXIS AND Z AXIS ACCURACY CHECKS

I. Equipment and materials

A. CNC lathe

B. Operator's manual

C. Dial indicator, 0.0001" accuracy

D. Magnetic base

E. Shop towels

II. Procedure

A. Power up machine and control

B. Set mode select switch to *JOG*

C. Press *HOME* button and note that it illuminates

D. Move the joystick to the X+ position and hold it until the X *HOME* light comes on

E. Move the joystick to the Z+ position and hold until the Z *HOME* light comes on

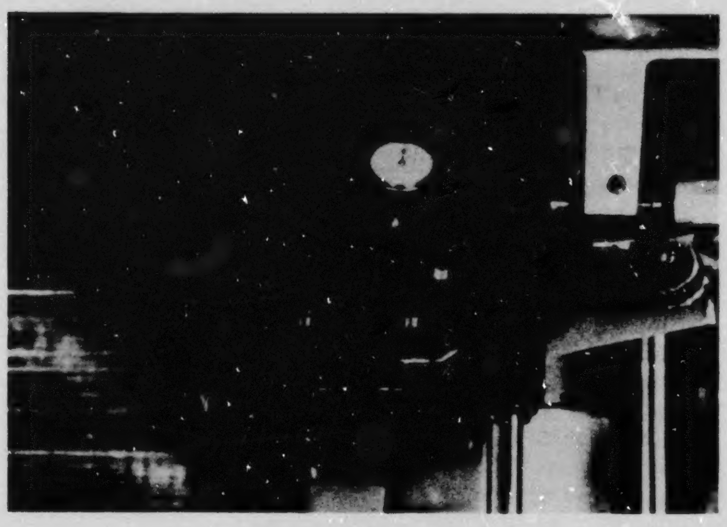
F. Press the *POS* key to set the CRT for position display

G. Attach the dial indicator to the magnetic base

JOB SHEET #2

H. Position the base on the machine so that the indicator plunger will rest against a smooth surface and show movement of the X axis (Figure 14)

FIGURE 14



I. Press the *PAGE* up button

(NOTE: The screen display will have U and W in the center.)

J. Press the U key on the keypad

K. Press the red *CAN* key and note that the *U* resets to zero

L. Set the mode select switch to *STEP*

M. Set the step feed increment to ten one-thousandths of an inch (0.010")

N. Zero the dial indicator

O. Move the joystick to the X− position until the CRT indicates 0.0200"

P. Move the joystick to the X+ position until the CRT indicates 0.0000"

Q. Check the indicator reading

1. If the reading is 0.0002" or less, continue with the procedure
2. If the reading is greater than 0.0002", contact your instructor

JOB SHEET #2

R. Reposition the indicator to read along the Z axis

S. Repeat steps J through O using the W key

T. Move the joystick to the Z− position until the CRT indicates a movement of 0.0200"

U. Move the joystick to the Z+ position until the CRT indicates 0.0000"

V. Check the indicator reading

   1. If the reading is 0.0002" or less, continue the procedure
   2. If the reading is greater than 0.0002", contact your instructor

W. Set the mode select switch to *MDI*

X. Shut down machine and control

Y. Put away equipment and materials; log procedure, if required

(NOTE: An accuracy check should be performed periodically, at least once every six months. For this reason, the shop may want to maintain records of when the checks are performed.)

POWER UP MACHINE AND CONTROL
UNIT II

TEST

NAME ______________________________ SCORE ______________

1. Match terms associated with machine and control power-up to their correct definitions. Write the correct numbers in the blanks.

______a. A number, letter, or combination of numbers and letters used to place the machine or control unit into various modes; also used to inform operator of operating status of machine or control unit

______b. Point along a given axis (X or Z) designated by the manufacturer for machine reference

______c. Command to move a given axis (X or Z) to its machine zero

______d. Process of loading information into the control using the keypad

______e. Code used to notify operator that an unsafe or damaging situation exists or has been commanded; also used to notify operator of improper commands

______f. Operating status of the machine or the control unit

______g. Letter used to designate the type of command addressed by a code

______h. Current control unit mode of operation, including all codes that are presently active

______i. To manually move an axis or the spindle

______j. To bring the machine and control unit from a power-off condition to an operating state

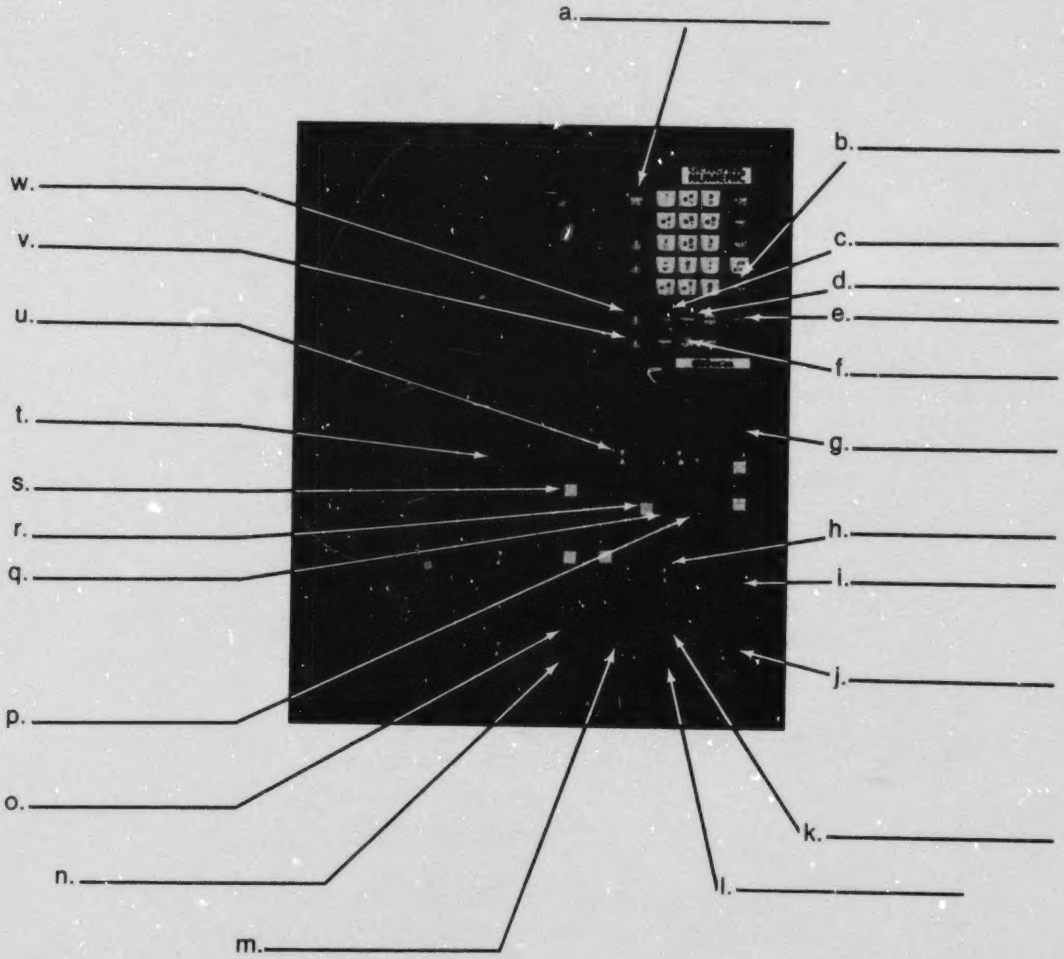
______k. Extreme limits of travel along axes

1. Machine home
2. Control status
3. Alarm code
4. Machine zero
5. Home (Zero-return)
6. Jog
7. Manual data input (MDI)
8. Power up
9. Mode
10. Code
11. Letter address

TEST

2. Identify controls and indicators used to power up, check, and shut down the machine. Write the names from the list below in the correct blanks.

Reset key
Close chuck button
Page up button
Joystick
E-stop button
Machine enable key switch
X home indicator
Mode select switch
Cancel key
Cycle start button
Spindle speed override switch
Feedhold button
Position key
Open chuck button
Jog CW button
Page down button
Program key
Jog CCW button
Turret button
Z home indicator
Input key
Operate/alarm key
Home button



TEST

3. Match controls and indicators used to power up, check, and shut down the machine to their correct functions. Place the number of the control or indicator beside its correct function.

______a. Used to reset alarm indicators and to cancel information input on the keypad prior to pressing the cycle start button

______b. Used to cancel information input on the keypad prior to pressing the input key

______c. Used to set the CRT to display positions of the axes

______d. Used to allow the operator access to the programmable portion of the control memory

______e. Used to store information fed through the keypad

______f. Used to check control status for valid alarms

______g. Used to begin sequence of operations input into control

______h. Used to set various operation modes for control, such as JOG and MDI

______i. Used to stop movement of axes

______j. Used to stop all movement of the machine, including spindle and coolant

______k. Used to close jaws

______l. Used to open jaws

______m. Used to provide power to or remove power from control unit

______n. Used to turn spindle clockwise for short intervals

______o. Used to turn spindle counterclockwise for short intervals

______p. Used to change CRT display by moving forward through pages

1. Home button
2. Operate/Alarm key
3. Input key
4. Z home indicator
5. Turret button
6. Jog CCW button
7. Program key
8. Page down key
9. Jog CW button
10. Open chuck button
11. Position key
12. Feed hold button
13. Spindle speed override switch
14. Cycle start button
15. Cancel key
16. Mode select switch
17. X home indicator
18. Machine enable key switch
19. E-stop button
20. Joystick
21. Page up key
22. Close chuck button
23. Reset key

TEST

_____q. Used to change CRT display by moving backwards through pages

_____r. Used to allow operator to manually adjust percentage of programmed spindle speed to be used

_____s. Used to make movements along X and Z axes

_____t. Used to index turret one station forward without using program command

_____u. Used to prepare control for movement of the axes to the home positions

_____v. Used to show when X axis reaches home position by illumination of light

_____w. Used to show when Z axis reaches home position by illumination of light

4. State functions of mode select switch positions used to start up, check, and shut down the machine. Write the functions in the blanks provided.

   a. MDI — ____

   ____

   b. Jog — ____

   ____

5. Describe the types of programming used in a CNC lathe. Write the descriptions in the blanks provided.

   a. Executive software — ____

   ____

   ____

   ____

   b. Part program — ____

   ____

   ____

   ____

TEST

6. Match letter addresses to their correct meanings. Write the correct numbers in the blanks.

_____a. Letter address for tool and offset commands

_____b. Letter address for commands that prepare the machine to make specific movements at specific rates or that causes specific functions; known as *preparatory functions*

_____c. Letter address for spindle speed commands

_____d. Letter address for miscellaneous function commands

_____e. Letter address for feed rate commands

_____f. Letter address for numbering sequences within a program

_____g. Letter address for numbering programs

1. F
2. G
3. M
4. S
5. T
6. O
7. N

7. Match selected G codes to their correct functions. Write the correct numbers in the blanks.

_____a. Directs control unit to generate a counterclockwise circular motion at the stored feed rate

_____b. Directs control unit to invoke constant surface speed (CSS) mode for spindle

_____c. Directs control unit to invoke a per minute feed rate

_____d. Directs control to use rapid traverse mode

_____e. Directs control unit to invoke a per revolution feed rate

_____f. Directs control unit to generate a clockwise circular motion at the stored feed rate

_____g. Directs control unit to use metric system

_____h. Directs control unit to generate a straight line at the stored feed rate

_____i. Directs control unit to use inch system

_____j. Directs control unit to invoke direct rpm for spindle

1. G00
2. G01
3. G02
4. G03
5. G20
6. G21
7. G96
8. G97
9. G98
10. G99

TEST

8. Match selected M codes to their correct functions. Write the correct numbers in the blanks.

______a. Directs control unit to start spindle in reverse (CCW) direction

______b. Directs control unit to stop coolant flow

______c. Directs control unit to start coolant flow

______d. Directs control unit to start spindle in forward (CW) direction

______e. Directs control unit to stop spindle

1. M03
2. M04
3. M05
4. M08
5. M09

9. Select from a list types of CRT displays. Write an "X" beside each correct display in the list below.

______a. Status display

______b. Input data display

______c. Executive software display

______d. Program and sequence number displays

______e. Preset position of X and Z axes in relation to home position

______f. Preset position in G50 coordinates

______g. Preset position in G40 coordinates

______h. Preset position in relative coordinates, absolute coordinates, machine coordinates, (distance from machine zero point); also shows distance left for each axis to travel in remaining part of the programmed operation

______i. Command data display of commands stored in portion of program

______j. Command data display of information on tape being loaded

______k. Command data display of command data being input with MDI

______l. Program data display of software available from manufacturer

______m. Program data for block of program currently in use with mode select switch in EDIT or AUTO

______n. Program data for block of program being executed and the block about to be executed with the mode select switch in any position other than EDIT or AUTO

______o. Offset data displays

TEST

10. State meaning of status display codes. Write the meaning of each code in the space provided.

a. NOT READY — ____

____

b. ALM — ____

____

c. EDIT — ____

____

d. SRCH — ____

____

11. Match alarm codes to their correct descriptions. Write the correct numbers in the blanks.

_____a. Indicates an excess drift error on the Z axis

_____b. Indicates that X axis has exceeded maximum travel distance in the – direction

_____c. Indicates an excess drift error on the X axis

_____d. Indicates that Z axis has exceeded maximum travel distance in the + direction

_____e. Indicates that X axis has exceeded maximum travel distance in the + direction

_____f. Indicates that too much force has been applied along either the X or Z axis

_____g. Indicates that Z axis has exceeded maximum travel distance in the – direction

1. +X
2. –X
3. +Z
4. –Z
5. 01
6. 15
7. 25

12. Complete statements about the operation of the joystick. Write in the word or words required to make correct statements of the sentences below.

Operation of the joystick:

a. Shifts in one of __________ directions to move axes

b. With mode select switch in __________, axis moves at increment setting each time joystick is moved to shifted position

TEST

c. With mode select switch in __________, axis moves continuously until it reaches limits as long as joystick is held in shifted position

d. With __________ light set, axis moves to __________ point and stops when joystick is shifted to + position and held

13. Describe the purposes of emergency stops and power switches.

    a. Emergency stop push button

    ____

    ____

    b. Main disconnect switch

    ____

    ____

    c. Machine enable key switch

    ____

    ____

(NOTE: Test questions 14-16 list the assignment sheets and job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

14. Complete a CNC turning safety test.

15. Troubleshoot alarm indications during power up.

16. Demonstrate the ability to

    a. Power up, check, and shut down a CNC lathe.

    b. Perform X axis and Z axis accuracy checks.

POWER UP MACHINE AND CONTROL
UNIT II

ANSWERS TO TEST

1. a. 10
   b. 4
   c. 5
   d. 7
   e. 3
   f. 9
   g. 4
   h. 2
   i. 6
   j. 8
   k. 1

2. a. Reset key
   b. Cancel key
   c. Position key
   d. Program key
   e. Input key
   f. Operate/Alarm key
   g. Cycle start button
   h. Mode select switch
   i. Feedhold button
   j. E-stop button
   k. Open check button
   l. Close chuck button
   m. Machine enable key switch
   n. Jog CW button
   o. Jog CCW button
   p. Z home indicator
   q. X home indicator
   r. Home button
   s. Turret button
   t. Joystick
   u. Spindle speed override switch
   v. Page down key
   w. Page up key

ANSWERS TO TEST

3.	a.	23	i.	12	q.	8
	b.	15	j.	19	r.	13
	c.	11	k.	22	s.	20
	d.	7	l.	10	t.	5
	e.	3	m.	18	u.	1
	f.	2	n.	9	v.	17
	g.	14	o.	6	w.	4
	h.	16	p.	21		

4. a. MDI — Used to allow operator to input data by means of the keypad

   b. Jog — Used to allow operator to jog the spindle with the jog CW and jog CCW buttons

5. a. Executive software — Information stored in control by the manufacturer that allows the machine to interpret codes and other functions; contains data that is not affected by operator-loaded information

   b. Part program — Information loaded into the control by the operator through the keypad or other means for temporary use in specific production operations

6.	a.	5	e.	1
	b.	2	f	7
	c.	4	g.	6
	d.	3		

7.	a.	4	f.	3
	b.	7	g.	6
	c.	9	h.	2
	d.	1	i.	5
	e.	10	j.	8

ANSWERS TO TEST

8. a. 2

b. 5

c. 4

d. 1

e. 3

9. a, b, d, e, f, h, i, k, m, n, o

10. a. NOT READY — Indicates that machine and control are not ready for operation during power up

b. ALM — Indicates that an alarm condition exists

c. EDIT — Indicates that control unit is performing edits specified by operator

d. SRCH — Indicates that control is searching for sequence number

11. a. 7

b. 2

c. 6

d. 3

e. 1

f. 5

g. 4

12. a. four

b. STEP

c. JOG

d. HOME, home

13. a. Emergency stop push button — Stops all machine functions immediately; locks in place when depressed; must be rotated clockwise to release

b. Main disconnect switch — Must be in the *ON* position to supply power to machine and control unit

c. Machine enable key switch — Must be in the *ON* position for machine operation in any mode

ANSWERS TO TEST

14. Evaluated to the satisfaction of the instructor

15. Evaluated to the satisfaction of the instructor

16. Performance skills evaluated to the satisfaction of the instructor

SET UP MACHINE AND TEST RUN PROGRAM
UNIT III

UNIT OBJECTIVE

After completing this unit, the student should be able to set up the machine to produce a given part when provided with a work order and a setup sheet. Once the machine has been set up, the student should then be able to test run the program. The student will show this knowledge by completing the assignment sheets and unit test with a minimum score of 85 percent and by completing a setup with no more than two errors in a time period specified by the instructor.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with setting up the machine to their correct definitions.
2. Match G and M codes associated with setup to their correct functions.
3. Select from a list correct guidelines for setup.
4. Name items of information that might be found on a work order.
5. Name items of information that might be found on a setup sheet.
6. Match jaws and collets to their correct uses.
7. Identify controls used to set up machine and test run program.
8. Match controls used to set up machine and test run program to their correct functions.
9. State functions of mode select switch positions used to set up machine and test run program.
10. Name methods of loading programs into a control unit.
11. Match components of program information to their correct descriptions.
12. Calculate offset values.
13. Interpret a work order.
14. Interpret a setup sheet.
15. Interpret CRT displays.
16. Demonstrate the ability to
    a. Prepare a work station for production.

OBJECTIVE SHEET

b. Set up jaws.

c. Load program.

d. Move U and W slides to program home position.

e. Determine initial offsets and store in control.

f. Test run program.

g. Edit program for first run.

SET UP MACHINE AND TEST RUN PROGRAM
UNIT III

INSTRUCTIONAL OVERVIEW

I. Unit contents

- A. Objective sheet
- B. Instructional overview (instructor copy)
- C. Instructional supplements (instructor copy)
- D. Information sheet
- E. Assignment sheets
  1. Assignment Sheet #1 — Interpret a Work Order
  2. Assignment Sheet #2 — Interpret a Setup Sheet
  3. Assignment Sheet #3 — Interpret CRT Displays
  4. Assignment Sheet #4 — Calculate Offsets
- F. Answers to assignment sheets (instructor copy)
- G. Job sheets
  1. Job Sheet #1 — Prepare a Work Station for Production
  2. Job Sheet #2 — Set Up Jaws
  3. Job Sheet #3 — Load Program
  4. Job Sheet #4 — Move U and W Slides to Program Home Position
  5. Job Sheet #5 — Determine Initial Offsets and Store in Control
  6. Job Sheet #6 — Test Run Program
  7. Job Sheet #7 — Edit Program for First Run
- H. Test
- I. Answers to test (instructor copy)

II. Suggested activities

- A. Review unit of instruction and plan method of presentation.

INSTRUCTIONAL OVERVIEW

B. Obtain materials necessary to supplement unit.

C. Make transparencies.

D. Introduce students to unit.

SUGGESTIONS:

- Emphasize how much time can be saved by carefully preparing for a job.
- Invite a shop supervisor to talk to the class about the importance of careful planning and setup.

  (NOTE: Some companies keep records on the time and money spent in each phase of production. These might be available for use in your classroom.)
- Use a Rubik's cube or similar puzzle to show how easily the solution can be found by applying a carefully organized, planned approach as opposed to a hit-and-miss method; relate this to thoughtful, planned production as opposed to trial-and-error methods.

E. Provide students with unit of instruction.

F. Discuss unit and specific objectives.

SUGGESTIONS:

- Show the students the ball peen hammer or other products to be completed in this course; use the product to relate the objectives to the production process.
- Demonstrate setting up the CNC lathe for production and point out how each objective will help the student master the setup process.

  (NOTE: You may choose to omit some of the objectives for experienced machinists. This may be done based on your knowledge of their abilities or by using the unit test as a pretest given before discussing the information sheet.)

G. Discuss information sheet.

1. Use Section I of the information sheet to discuss terms associated with machine set up; have examples of the tools and materials to be discussed.

INSTRUCTIONAL OVERVIEW

2. Use Section II of the information sheet and the control unit operator's manual to discuss the given G and M codes.

   SUGGESTIONS:

   - As you discuss the codes, allow the students to suggest uses for the various codes in actual machining.
   - Demonstrate the codes on the machine.

3. Use Section III of the information sheet to discuss guidelines for setup.

   SUGGESTIONS:

   - Have the students measure the distance from the CNC lathe to the tool room and time how long it takes to go get a tool; have them calculate how many miles they would walk and how much time it would take if they make five extra trips to the tool room per day in a 240-workday year.
   - Display tools, cutters, collets, *etc.* that have been misused and emphasize the importance of selecting the proper tools and materials.

4. Use Section IV of the information sheet to discuss work orders.

   SUGGESTIONS:

   - Have an industry representative talk to the class about how they use work orders, emphasizing the importance of work orders in maintaining production records and controlling costs.
   - Use Transparency #1 or examples of work orders for the students to view during the discussion.
   - Make a bulletin board of various types of work orders from different companies.
   - Use Assignment Sheet #1 to reinforce the objective.

5. Use Section V of the information sheet to discuss setup sheets.

   SUGGESTIONS:

   - Use a panel of shop supervisors or production personnel to discuss methods of using setup sheets and their role in the production process.

INSTRUCTIONAL OVERVIEW

- Use Transparency #2 or examples of setup sheets for the students to view during the discussion.

- Demonstrate Job Sheet #1 and allow students to practice.

6. Use Section VI of the information sheet to discuss jaws and collets.

SUGGESTIONS:

- Put up posters and bulletins dealing with the safe use of jaws and collets.

- Demonstrate Job Sheet #2 and allow students to practice; reinforce objectives 5 and 6 by using Assignment Sheet #3.

- Have someone familiar with shop injuries or who has been severely injured by an improper jaw or collet installation talk about such injuries.

- Display tools and workpieces damaged through the improper use of jaws and collets.

7. Use Section VII of the information sheet to point out the location of controls used to set up the machine and test run the program; emphasize that other controls discussed in previous units are also used, but these additional controls are also used.

8. Use Section VIII of the information sheet to discuss the functions of the controls introduced in Section VII.

SUGGESTIONS:

- Emphasize the controls and CRT displays as you demonstrate procedures.

- Place special emphasis on the EOB key and how it is registered on the CRT and on program printouts.

- Review controls and indicators learned earlier and relate them to the new controls.

9. Use Section IX of the information sheet to introduce the mode select switch positions used to set up the machine and test run the program.

SUGGESTIONS:

- Demonstrate the new switch positions and the effects on machine operation.

INSTRUCTIONAL OVERVIEW

- Review switch positions covered in previous units; emphasize that those positions are also used to set up the machine and test run the program.

- Use Assignment Sheet #3 to quiz the students on CRT displays as you demonstrate control functions.

10. Use Section X of the information sheet to discuss methods of program loading.

SUGGESTIONS:

- Display the various types of tapes used in program loading.

- Display rough and edited programs for various production jobs.

- Demonstrate each method of loading.

11. Use Section XI of the information sheet to discuss components of a program.

SUGGESTIONS:

- Use actual program printouts in discussing components of a program.

- Emphasize data blocks that deal with set up status and offsets.

- Review letter addresses and *G* and *M* codes.

- Demonstrate an edit and an offset change, emphasizing changes made on the CRT and program notes that the operator should make.

12. Use Section XII of the information sheet to discuss calculating offsets.

SUGGESTIONS:

- Use the machine to demonstrate how important correct offsets are.

- Point out on a blueprint how many offsets may be required on a production job.

- Demonstrate how the control unit can be helpful in detecting incorrect offsets.

- Use Assignment Sheet #4 to allow students an opportunity to practice calculating offsets.

  (NOTE: Make sure that students understand that the term *offsets* has several different uses in CNC turning. Clarify the reason for listing a tool position offset on a setup sheet or program. Distinguish between initial offset values and revised offsets for editing or tool wear. You may wish to demonstrate offsets by inputting some and showing the students how the X and Z registers or the U and W registers are affected.)

H. Demonstrate and discuss job sheets.

SUGGESTIONS:

- Show the videotapes of the job sheet procedures.
- Use the work order and setup sheet provided for the ball peen hammer or others from actual jobs.
- Allow the students to practice the job sheet procedures and keep records of how they could have improved their performance through better setup planning—such as gathering all required tools, rearranging the tool placement, adding or omitting program steps, *etc.*
- Use the procedure for boring soft jaws as a good first machining operation on the CNC lathe.
- After the students have practiced Job Sheets #1 and #2, use Assignment Sheet #3 to reinforce the objectives.

I. Give test.

J. Reteach and retest if necessary.

INSTRUCTIONAL OVERVIEW

PROGRAM PRINTOUT
FOR HAMMERHEAD, FIRST SETUP

(NOTE: You may wish to make several tapes with slight changes in this program to allow the students practice in program editing as a part of the test run.)

```
N0001G00G20G99
N0002G50X15.5Z16.625S2000
N0003G96S0400M03
N0004T0100
N0005G00X1.65Z.1T0101M08
N0006G94X0Z0F.008F.012
N0006G90X1.4Z-2.25
N0006X1.3Z-2.25
N0006X1.2Z-1.05
N0006X1.1Z-1.05
N0007G90X1.Z-1.050
N0008X.90Z-.282
N0009X.8Z-.2
N0010X.70Z-.1429
N0011X.6Z-.1
N0012X.50Z-.0669
N0013X.4Z-.0417
N0017G00X0Z.1
N0018G01Z0
N0019G01X-.04
N0020X0
N0021G03X1.Z-.5R.5F.008
N0022G01Z-1.0802
N0023G00X2.
N0024G00X15.5Z16.625T0100
N0025M05

N0027G00G20G99
N0028G50X15.5Z16.625S2000
N0029G96S0400M03
N0030T0300
N0031G00M08X1.Z.1T0303
N0033G01X1.1Z.0999
N0034X1.0988Z-.4776
N0035G03X1.0342Z-.551R.1
N0036G02X1.2262Z-1.0902R.325
N0037G01X1.2264Z-1.0903
N0038G03X1.35Z-1.1827R.1
N0040S0500
N0041G00X2.
N0042Z.1
N0043X1.
N0044G01
N0045X1.03Z.0999
N0046X1.0288Z-.4775
```

INSTRUCTIONAL OVERVIEW

PROGRAM PRINTOUT
FOR HAMMERHEAD, FIRST SETUP (CONT.)

```
N0047G03X.9868Z-.5253R.065
N0048G02X1.0006Z-1.1226R.36
N0049G03X1.28Z-1.1827R.065
N0050G01Z-2.2479
N0051G00X2.
N0052Z.1
N0053X1.
N0054G01
N0055X.9988Z-.4775
N0056G03X.9666Z-.5142R.05
N0057G02X1.1882Z-1.1365R.375
N0058G03X1.25Z-1.1827R.05
N0059G01Z-2.2479
N0060G00X2.
N0061G00X15.5Z16.625T0300
N0062M05
N0063M30
```

INSTRUCTIONAL OVERVIEW

PROGRAM PRINTOUT FOR HAMMERHEAD, SECOND SETUP

```
N0001G00G20G99
N0002G50X15.5Z17.25S2000
N0003G96S0400M04
N0004T0100
N0005G00X1.5Z.1M08T0101
N0006G94X0Z.01F.01
N0012G90X1.4Z-1.7
N0013X1.3
N0014X1.17Z-1.5869
N0015G00X0
N0016G01Z0
N0017X1.0686Z-.0467
N0018G03X1.16Z-.0965R.05
N0019G01Z-1.5869
N0020G00X2.
N0021G00X15.5Z17.25T0100
N0022T0100M05
N0023M00

N0024G00G20G99
N0025G50X15.5Z17.25S2000
N0026G96S0400M04
N0027T0300
N0028G00X1.16Z.1T0303
N0029G01F.012
N0030X1.26
N0031Z-.9006
N0032G03X1.1682Z-.9846R.1
N0033G01X1.168Z-.9847
N0034G02X1.2366Z-1.5505R.325
N0035G01X1.237Z-1.5506
N0036G03X1.35Z-1.6406R.1
N0037G01Z-1.7
N0038G00X2.
N0039Z.1
N0040X1.16
N0041G01S0500
N0042X1.19
N0043Z-.9006
N0044G03X1.1302Z-.9552R.065
N0045G02X1.2062Z-1.582R.36
```

INSTRUCTIONAL OVERVIEW

PROGRAM PRINTOUT FOR HAMMERHEAD, SECOND SETUP (CONT.)

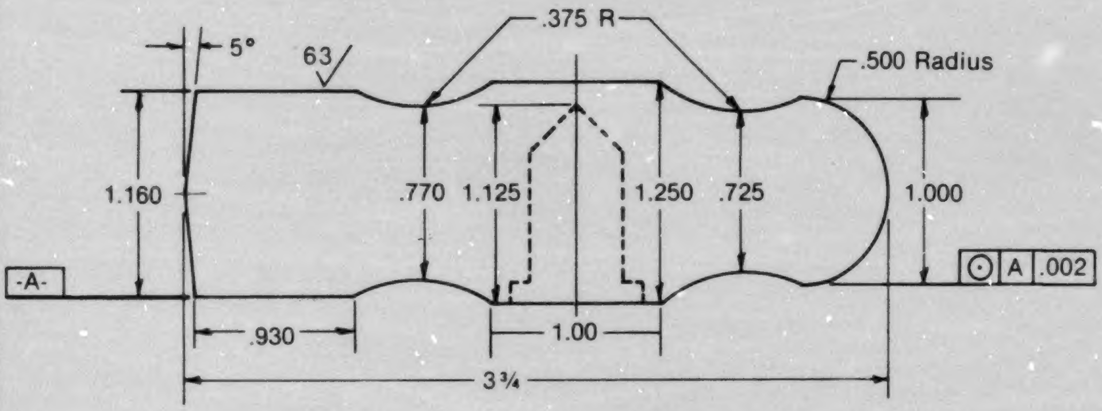
```
N0046G01X1.2066Z-1.5821
N0047G03X1.28Z-1.6406R.065
N0048G01Z-1.7
N0049G00X2.
N0050Z.1
N0051X1.16
N0052G01
N0053Z-.9006
N0054G03X1.114Z-.9426R.05
N0055G02X1.1932Z-1.5955R.375
N0056G01X1.1934Z-1.5956
N0057G03X1.25Z-1.6406R.05
N0058G01Z-1.7
N0059G00X2.
N0060G00X15.5Z17.25T0300
N0061T0300M05
```

DO NOT FILM THIS PAGE

WORK ORDER

Part Number	010101	**Shop Order Number**	0001
Part Name	Head, Hammer	**Date of Issue**	07/01/84
Quantity	0010	**Due Date**	07/25/84
Material	AISI 4140 HR ANN		

OPER. NO.	WORK CENTER	DESCRIPTION	SETUP STD.	RUN STD.
010	0001	Saw Cut to 3 7/8" Lg.	00.10	0.016
020	0006	Face, Turn, and Profile Per Tape #SM-001	02.00	0.083
030	0006	Face, Turn, and Profile Per Tape #SM-002	02.00	0.038
040	0010	Inspect		
050	0003	Drill, C'Bore, and Tap	01.50	0.075
060	0010	Inspect		
070		Heat Treat		
080	0010	Check Hardness RC 40-50		
090	0020	Stores		



5°
63
.375 R
.500 Radius
1.160
.770
1.125
1.250
.725
1.000
-A-
A
.002
.930
1.00
3¾

NOTES: 5/8"-18 Tap to 1 1/4"
37/64" Drill
3/4" Counterbore to clean up

MATERIAL: 1 1/4" Diameter stock

CNC - 131

Set-Up Sheet

Part Name Hammer head

Operation # 020

Part No. 010101

Date

Tape No. SM-001

Prog. by K. Sloan

First Run 7/1/84

Revised K. Sloan 7/1/84

Home Position U Home W Home

Chucking Details ☒ Hard ☐ Soft

Max. Gripping Length 2 3/8"

Jaw No.

Comments to Oper. Cut Stock 3 7/8" long

Tool	Offset	Tool Ident. No.	Tool Desc.	Insert	Grade	Radius
1	1	MCLNL-16-3	80° Left	CNMM 322		1/32
2						
3	3	MDJNL-16-3	55° Left	DNMM 322		1/32
4						
5						
6						
7						
8						

CNC - 133

Set-Up Sheet

Part Name Hammer head
Operation # 030
Part No. 010101
Date
Tape No. SM-002
Prog. by K. Sloan
First Run 7/1/84
Revised K. Sloan 7/1/84
Home Position U Home W Home
Chucking Details ☐ Hard ☒ Soft
Max. Gripping Length
Jaw No.
Comments to Oper. Bore soft JAWS 1.25 x 7/8" Deep

Tool	Offset	Tool Ident. No.	Tool Desc.	Insert	Grade	Radius
1	1	SCLNL-16-3	80° Left	CNMM 322		1/32
2						
3	3	SDJNL-16-3	55° Left	DNMM 322		1/32
4						
5						
6						
7						
8						

TM #3

Set-Up Sheet

Part Name________________ Operation # ______________

Part No.________________ Date ______________

Tape No.________________ Prog. by______________

First Run________________ Revised______________

Home Position U______________ W______________

Chucking Details ☐ Hard ☐ Soft

Max. Gripping Length____________________________

Jaw No.____________________________

Comments to Oper. ____________________________

Tool	Offset	Tool Ident. No.	Tool Desc.	Insert	Grade	Radius
1						
2						
3						
4						
5						
6						
7						
8						

SET UP MACHINE AND TEST RUN PROGRAM
UNIT III

INFORMATION SHEET

I. Terms and definitions

A. Set up — To prepare the machine and control unit with the necessary tooling and programming required for a particular production

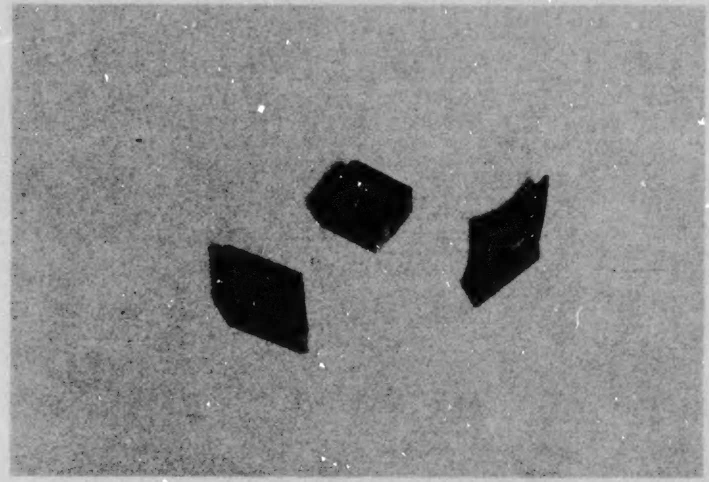
B. Tooling — Tools and holding devices required for a setup

C. Tool holder — Device for holding cutting tools

D. Carbide insert — Carbide cutting tool that can be quickly inserted into or removed from a special holder (Figure 1)

EXAMPLE:

FIGURE 1



E. Collet — Holding device available in various diameters for different sizes of workpieces or straight-shank tools

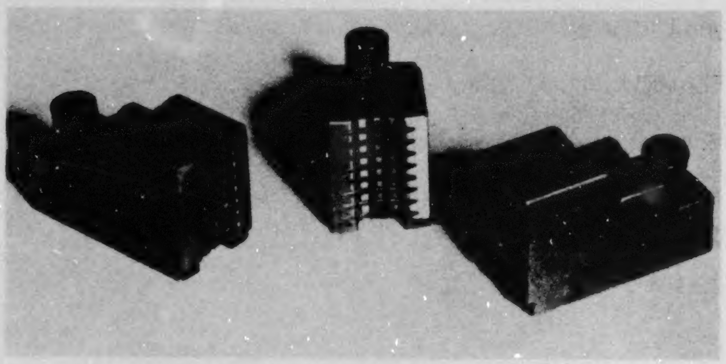
INFORMATION SHEET

F. Hard jaws — Hardened, serrated chuck jaws (Figure 2)

(NOTE: The serrations are ridges machined into the jaws to allow a more secure grip on the workpiece.)

EXAMPLE:

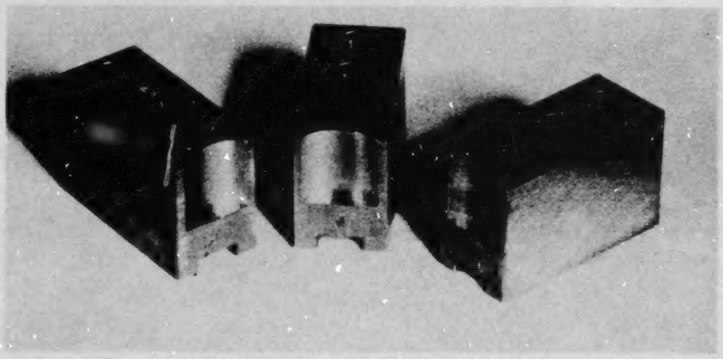
FIGURE 2



G. Soft jaws — Chuck jaws made of a soft material so that they may be machined to fit a particular part (Figure 3)

EXAMPLE:

FIGURE 3



INFORMATION SHEET

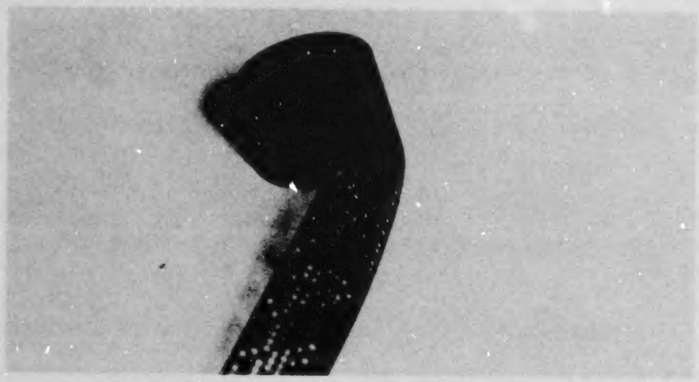
H. Setup sheet — Document prepared by the programmer to inform CNC turning technician of tools to be used and the position of those tools

I. NC tape — One-inch wide paper or mylar tape punched with program information (Figure 4)

(NOTE: NC tape is one of four ways of loading information into the control unit.)

EXAMPLE:

FIGURE 4



J. NC readout (NC manuscript) — Printed copy of all information contained on an NC tape

K. Test run — Operation of a CNC program with all tooling but no workpiece

(NOTE: A test run is normally done to check a program to make sure that all the machining operations are included on the program and that the operations can be performed without damage to the tooling or machine. A process discussed in a later unit, *first run*, is used to check the workpiece produced by a program.)

L. Edit — To make changes in a program or in the program stored in the control unit memory

M. Offset value — Difference between the size of a part according to the program and the actual size machined

INFORMATION SHEET

II. G and M codes associated with set up

- A. G00 — Causes all machine movements to be made in rapid traverse mode
- B. G01 — Causes machine to follow straight line between two specified points

  (NOTE: The generation of a line between two specified points is called *linear interpolation.*)
- C. G02 — Causes machine to follow clockwise arc between two specified points

  (NOTE: The generation of a clockwise arc between two specified points is called *clockwise circular interpolation* or *CW circular interpolation.*)
- D. G03 — Causes the machine to follow a counterclockwise arc between two specific points

  (NOTE: The generation of a counterclockwise arc between two specific points is called *counterclockwise circular interpolation* or *CCW circular interpolation.*)
- E. G50 — Presets axis registers and limits maximum spindle speed; used to define the location of a tool point
- F. M00 — Causes the machine and control unit to stop all activities and processing until the *CYCLE START* button is pressed

  (NOTE: M00 is known as the *program stop code.*)
- G. M08 — Causes coolant flow to begin
- H. M09 — Stops coolant flow
- I. M30 — Signals end of program and causes machine to reset to control status at beginning of program

III. Guidelines for set up

- A. Clean machine and work area before starting any new job
- B. Check setup sheet prior to returning tools from previous job to see if any of them may be used for the next job
- C. Perform quick preventive maintenance inspection after extended machine operation
- D. Obtain necessary tools, equipment, and materials

INFORMATION SHEET

   E. Review setup sheet and install tooling properly

   F. Study work order and setup sheet to become familiar with workpiece design and required operations

IV. Work order information

(NOTE: A work order may also be referred to as a *route sheet* or a *process sheet.*)

   A. Name and number of part or job

   B. Work order number

   C. Page number if more than one page

   D. Part print

   E. Material specifications

   F. Required operations

   G. Number of parts required

   H. Program numbers

   I. Production deadline

   J. Authorization

   K. Standard times required for setup and production operations

V. Setup sheet information

   A. Part and operation identification

   B. Tools required

   C. Tool positions

   D. Sequence of operations

   E. Special instructions to operator

   F. Program home position

   G. Programming information

INFORMATION SHEET

VI. Uses of jaws and collets

A. Soft jaws — Machined to fit workpieces to protect machined surfaces or to allow concentric machining

B. Two-jaw chuck — Used to hold irregular and nonsymmetrical workpieces

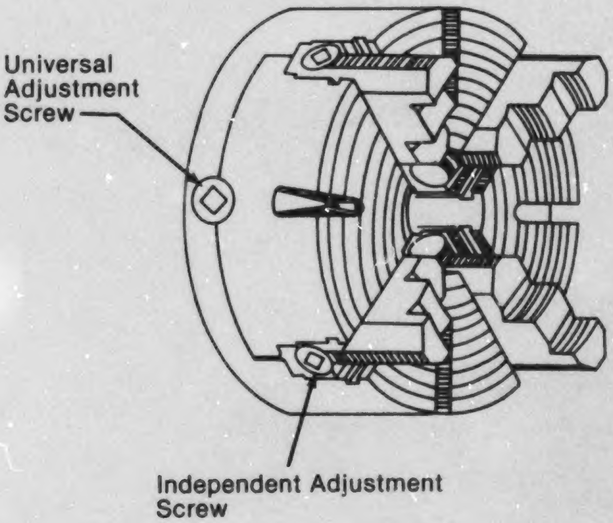
C. Three-jaw chuck — Used to hold symmetrical workpieces on center

D. Four-jaw chuck — Used to hold regular or irregular workpieces on- or off-center (Figure 5)

(NOTE: On most three-jaw chucks, the jaws move together to keep a concentric holding area. Many four-jaw chucks use jaws that can be moved independently of each other.)

EXAMPLE:

FIGURE 5



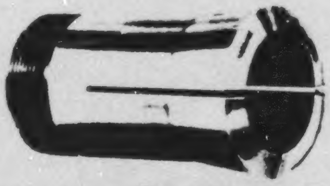
INFORMATION SHEET

E. **Collet** — Used to hold small semifinished or finished parts so that additional symmetrical, on-center operations can be performed

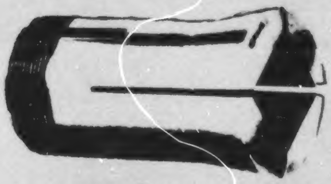
(NOTE: Collets come in a number of sizes and shapes to hold specific workpiece designs. Figure 6 shows some of the more common shapes.)

EXAMPLES:

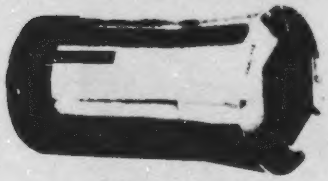
FIGURE 6



Round



Square



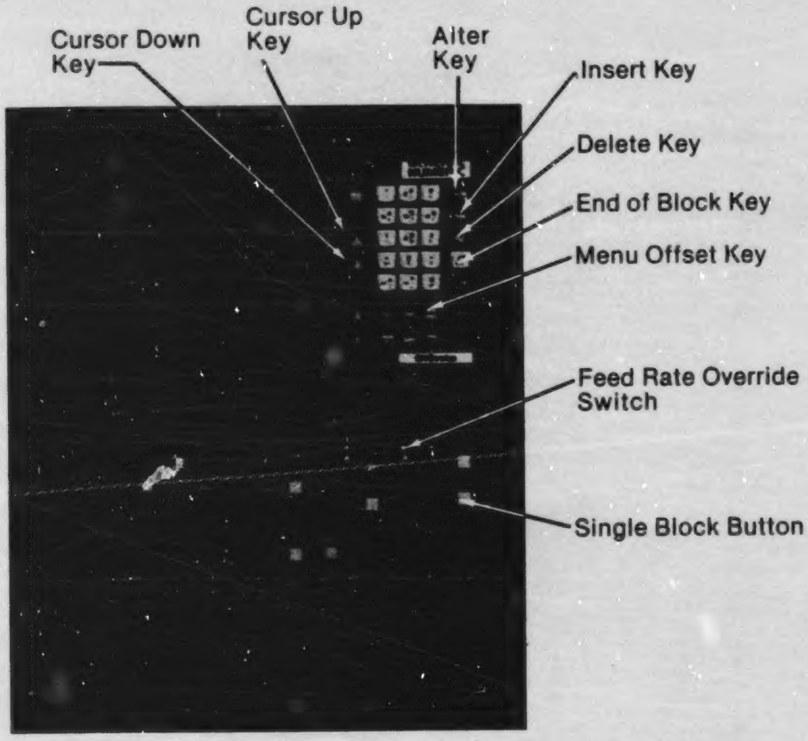
Hexagonal

INFORMATION SHEET

VII. Controls used to set up machine and test run program (Figure 7)

(NOTE: Following this information sheet, there is a detailed photograph of the control unit. You may want to study it and use it to follow the procedures in job sheets in this and other units.)

FIGURE 7


Cursor Down Key
Cursor Up Key
Alter Key
Insert Key
Delete Key
End of Block Key
Menu Offset Key
Feed Rate Override Switch
Single Block Button

INFORMATION SHEET

VIII. Functions of controls used to set up machine and test run program

A. Cursor down key — Moves cursor forward on CRT display one line for each time the button is pushed

B. Cursor up key — Moves cursor up on CRT display one line for each time the button is pushed

C. Alter key — Allows operator to change stored information to data input on keypad following letter address

D. Insert key — Allows operator to insert information to the right of a point marked by the cursor

E. Delete key — Allows operator to delete information at a point marked by the cursor

F. End of block (EOB) key — Allows operator to indicate end of data block when keying in data

(NOTE: Pressing the EOB key will produce an asterisk [*] to indicate EOB on program print.)

G. Menu offset key — Allows operator to input tool offset values

H. Feed rate override switch — Allows operator to manually set feed rate at a percentage of the programmed feed rate

EXAMPLES: If the program feed rate is 0.020 inches per revolution and the feed rate override switch is set for 100 percent, the machine will feed at 0.020 ipr; if the override switch is set for 50 percent, the machine will feed at 0.010 ipr.

I. Single block button — Allows operator to direct machine to execute only one block of a program at a time and stop

(NOTE: The operator presses the CYCLE START button to continue execution of the program.)

IX. Mode select switch positions used to set up machine and test run program

A. EDIT — Used to make changes to program stored in control

B. AUTO — Used to allow machine operation by program commands

C. STEP — Used to move axes in short movements as determined by the step feed increment setting

INFORMATION SHEET

X. Methods of loading program

A. NC tape — Data is stored on paper or mylar tape and loaded through a tape reader

B. MDI — Data is input through keypad by operator or setup person

C. Bubble cassette — Data is stored on a special cassette tape and loaded through a tape recorder

D. Downloading from another computer — Data from one computer is transferred to another

(NOTE: A program may be loaded from another computer or another computer may be used to operate the CNC machine.)

XI. Components of program information

A. Program number — Four-digit number and the letter *O* used to identify a program

EXAMPLE: O 0001

B. Sequence number — Four-digit number and the letter *N* used to identify a portion of a program

(NOTE: Programs are generally broken down into sequences. A sequence is a portion of the machining operation. The use of sequence numbers makes it easier to locate portions of the program that must be edited or repeated.)

EXAMPLE: N 0014

C. Block — Minimum amount of data that is necessary to command the machine to perform a function, either internally or externally

(NOTE: A block consists of the sequence number and the command data.)

EXAMPLE: N0020 G50 X7.75 Z18.585 S2000

D. Word — Minimum unit of a block; consists of a letter address and the numerical data

EXAMPLE: G50

E. Address (letter address) — Letter portion of a word

F. Data — Numerical portion of a word, including the sign

EXAMPLE: X – 1.275

INFORMATION SHEET

XII. Calculating offset values

(NOTE: Offsets are required to correct part dimension errors that result from setup inadequacies or tool wear.)

A. To calculate X offsets, use the formula

$X_o = D_p - D_w$

Where D_p is the diameter from the print or program and D_w is the actual diameter of the workpiece

(NOTE: This formula gives the offset value to be entered into the *U* offset register. To center the correct *X* offset value, you must add the *U* offset to any other *X* offset value stored in the control.)

EXAMPLE: Part produced has a diameter of 3.015", but the blueprint calls for a 3.012" diameter

$$\begin{aligned} X_o &= D_p - D_w \\ &= 3.012'' - 3.015'' \\ &= -0.003'' \end{aligned}$$

(NOTE: An offset may be + or – and it is very important to enter the proper sign with the offset value.)

B. Calculate Z offsets, use the formula

$Z_o = L_w - L_p$

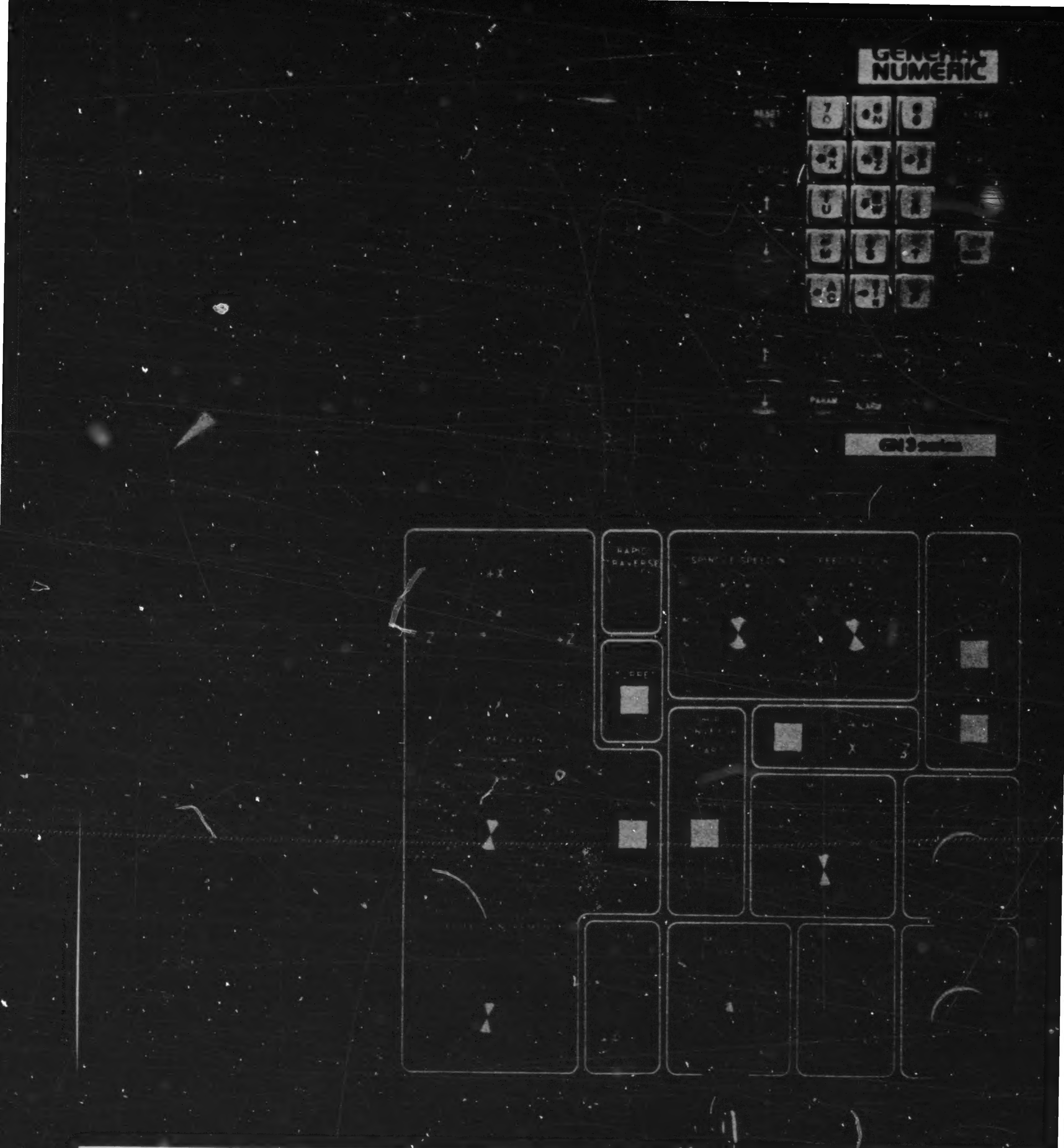
Where L_w is the actual length machined on the workpiece and L_p is the length called for on the print or program

(NOTE: This formula gives the offset value to be entered into the *W* offset register. To enter the correct *Z* offset value, you must add the *W* offset to any other *Z* offset value stored in the control.)

EXAMPLE: A shoulder on a part has a length of 0.665", but the program Z register value is 0.656"

$$\begin{aligned} Z_o &= L_w - L_p \\ &= 0.665'' - 0.656'' \\ &= 0.009'' \end{aligned}$$

(NOTE: Program dimensions can be determined from the program printout or from the axis register values.)


GENERAL
NUMERIC
PARAM
GN 3 series
+X
-Z
+Z
RAPID TRAVERSE
SPINDLE SPEED
FEEDRATE
X
Z

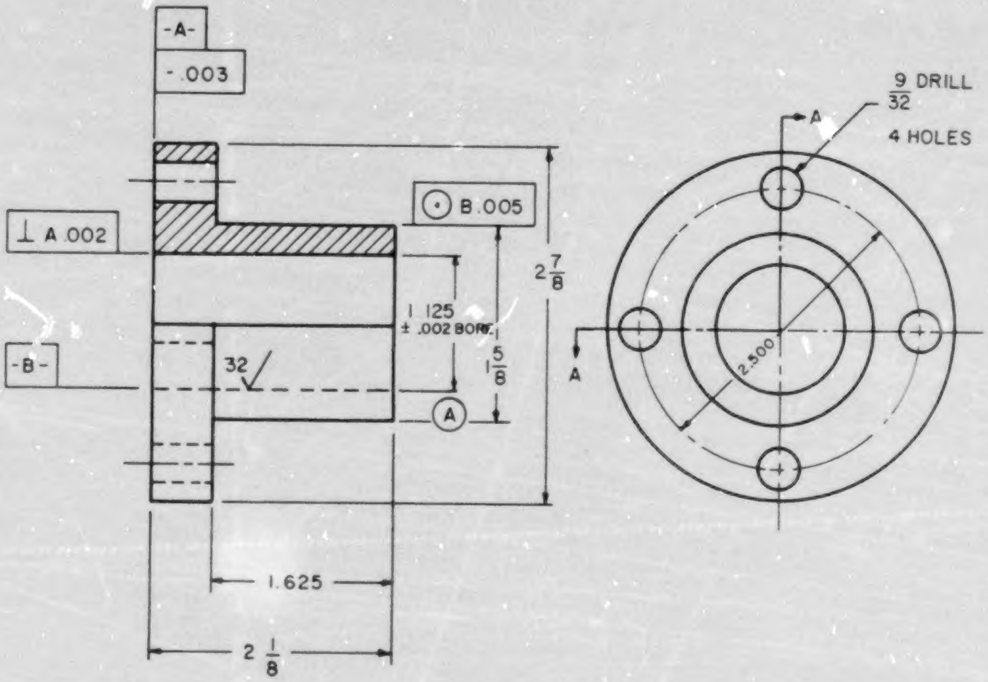
BEST COPY AVAILABLE

SET UP MACHINE
AND TEST RUN PROGRAM
UNIT III

ASSIGNMENT SHEET #1 — INTERPRET A WORK ORDER

NAME ________________________________ SCORE ______________

As a CNC turning technician, most of the instructions you receive concerning parts production will be in the form of work orders. Therefore, it is essential that you be able to understand correctly the instructions given on a work order. Study the following work order and answer the questions on the next page.



-A-
-.003
⊥ A .002
-B-
⊙ B .005
32
1.125
± .002 BORE
1 5/8
2 7/8
Ⓐ
1.625
2 1/8
9/32 DRILL
4 HOLES
A
A
2.500

(NOTE: Use tolerances of ± 0.001" for decimal dimensions and ± 1/64" for fractional dimensions.)

ASSIGNMENT SHEET #1

PART NUMBER	02002	SHOP ORDER NUMBER	12345
PART NAME	FLANGED BUSHING	DATE OF ISSUE	07/01/84
QUANTITY	100	DUE DATE	08/01/84
MATERIAL	CAST IRON		

OPER. NO.	WORK CENTER	DESCRIPTION	SETUP STD.	RUN STD.
0010	0001	SAW TO 2 ¼"	00.10	0.016
0020	0006	FACE, TURN, DRL, BORE PER TP# SM-003	02.00	0.125
0030	0006	FACE AND TURN PER TP# SM-004	01.50	0.065
0040	0003	DRILL 4 HOLES	01.00	0.035
0050	0000	INSPECT		
0060	0020	STORES		

DO NOT FILM THIS PAGE

ASSIGNMENT SHEET #1

A. What type of part is shown? ______________________

B. What is the shop order number? ______________________

C. What type of material is to be used? ______________________

D. How many of this part are required? ______________________

E. Is heat treatment required? ______________________

F. What is the standard time allowed to setup for the first operation? ______________

G. What is the maximum allowable length of the part? ______________

H. What tape number is to be used for the third operation? ______________

I. At which work center will the inspection be done? ______________

J. What is the standard time allowed to perform the second operation? ______________

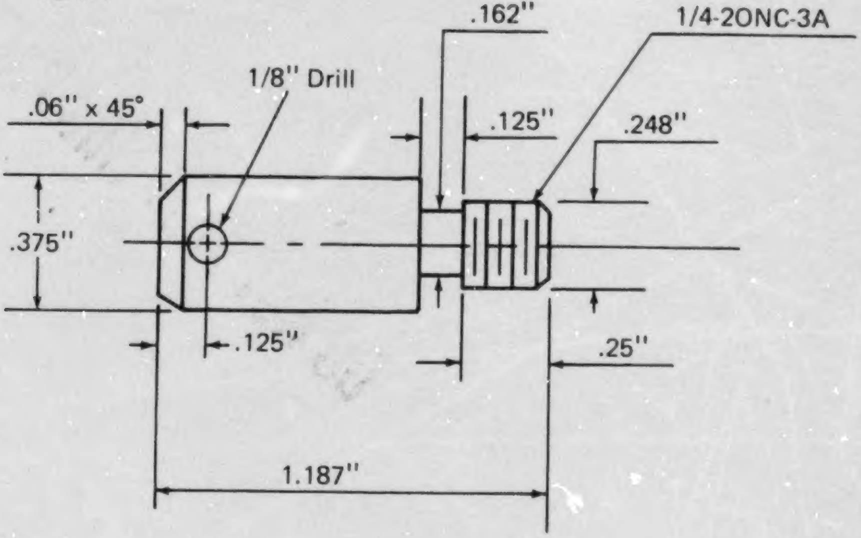
SET UP MACHINE
UNIT III

ASSIGNMENT SHEET #2 — INTERPRET A SETUP SHEET

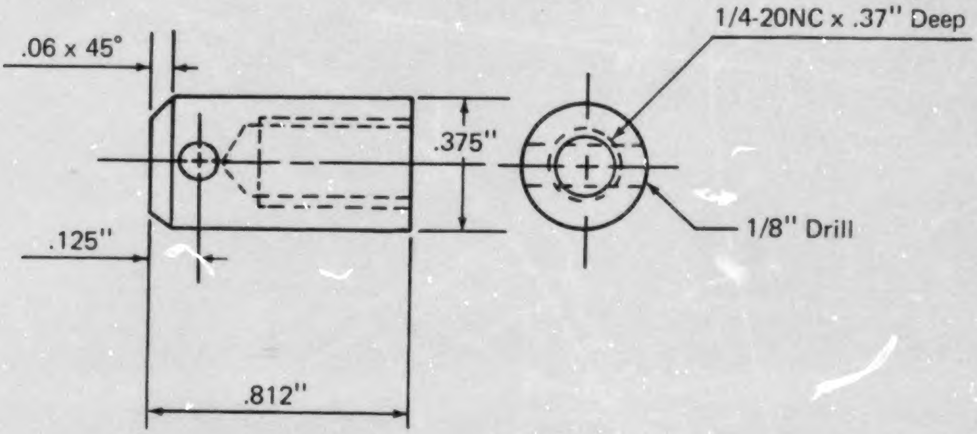
NAME ______________________________ SCORE ______________

A great deal of effort and planning goes into creating efficient setup sheets. For total effectiveness, the tool preset person or machine operator must be able to read and understand a setup sheet. Using the blueprint below and the setup sheet on the following page, check out the tools and materials needed to produce Part A. Your instructor will assign you a machine lathe to set up and will inspect your work when you have completed the assignment. Next, reset the machine for Part B and have your instructor check that setup.

Part A


.162"
1/4-2ONC-3A
1/8" Drill
.06" x 45°
.125"
.248"
.375"
.125"
.25"
1.187"

Part B


Drill #7 x .5" deep
1/4-20NC x .37" Deep
.06 x 45°
.375"
1/8" Drill
.125"
.812"

CNC - 157

Set-Up Sheet

Part Name Key Ring (A)

Operation # 03

Part No. 84-0614-A

Date 7/2/84

Tape No. KR-117

Prog. by RWH

First Run 7/3/84 RWH

Revised 7/3/84 RWH

Home Position U Home W Home

Chucking Details ☑ Hard ☐ Soft

Max. Gripping Length 2.5"

Jaw No.

Comments to Oper.

Tool	Offset	Tool Ident. No.	Tool Desc.	Insert	Grade	Radius
1	1	MCLNL 16-4	Turning	CNMG 432	C-6	1/32
2						
3	3	NSR-163	Recessing	NG 3125 R	C-6	0
4						
5	5	NSR-163	Threading	NT 3R	C-6	0
6						
7	7		Cut off			1/8
8						

CNC - 159

Set-Up Sheet

Part Name Key Ring (B)

Operation # 04

Part No. 84-0614-B

Date 7/2/84

Tape No. KR-118

Prog. by RWH

First Run 7/3/84 RWH

Revised 7/3/84 RWH

Home Position U Home W Home

Chucking Details ☑ Hard ☐ Soft

Max. Gripping Length 1.5"

Jaw No.

Comments to Oper.

Tool	Offset	Tool Ident. No.	Tool Desc.	Insert	Grade	Radius
1	1	MCLNL 16-4	Turning	CNMG 432	C-6	1/32
2						
3	3		Drill #7			
4						
5	5	NSR -163	Threading	NT 3R	C-6	0
6						
7	7		Cutoff			1/8
8						

SET UP MACHINE AND TEST RUN PROGRAM
UNIT III

ASSIGNMENT SHEET #3 — INTERPRET CRT DISPLAYS

NAME ________________________ SCORE ____________

The CRT provides essential information for the CNC turning technician to use during programming and operation of the machine. Using the CRT, the technician can determine positions of tools, diagnose alarm conditions, read program information, monitor operations, and interpret a number of other bits of information regarding commands and machine status. Your instructor will operate the CNC lathe to demonstrate procedures to you. During the demonstration, he will ask you questions about the information on the CRT displays. Use the space below and on the next page to answer questions.

SET UP MACHINE AND TEST RUN PROGRAM
UNIT III

ASSIGNMENT SHEET #4 — CALCULATE OFFSETS

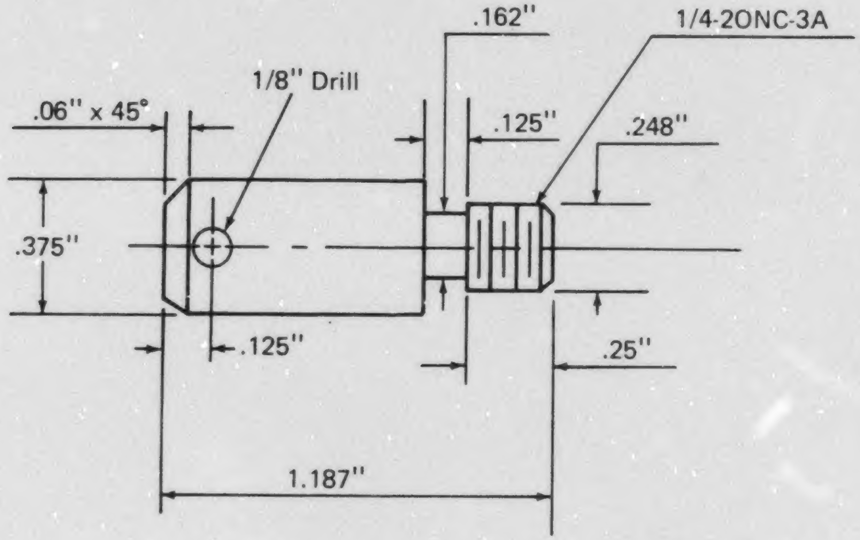
NAME ______________________________ SCORE ____________

Accuracy in numerical machinery depends on all the programmed points being correct. As the CNC machine is set up the offsets for each tool must be determined and stored in the control as described in Job Sheet #5. After the test run of the program it may be necessary to revise some of the offsets. Additionally, to maintain required accuracy, offsets are sometimes changed during the machining. These requirements point out how critical it is that CNC turning technicians be able to calculate offsets.

Read the situations described below and calculate the required offsets. Show your work and be sure to include the appropriate + or − sign and axis with your answer.

A. During the process of determining initial offsets for the part below, the X register shows a diameter of 0.478" and the part measures 0.481" after the first rough cut of 1/2" stock. What offset is required?

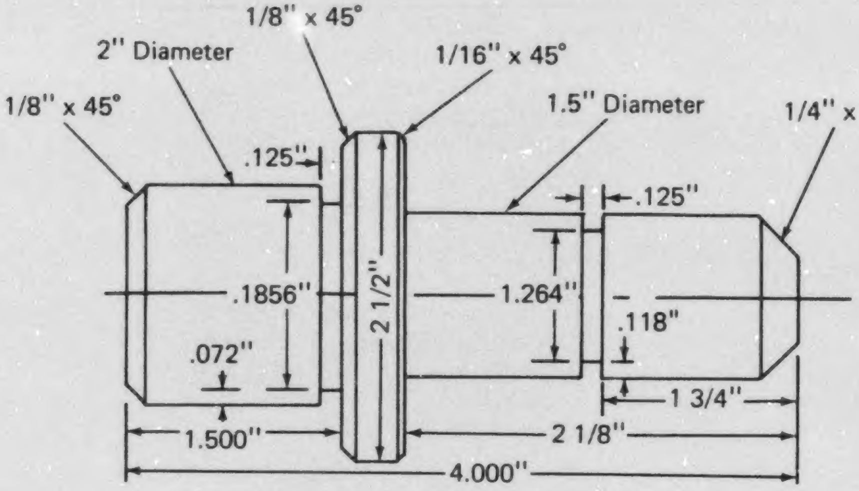
Offset ____________________



ASSIGNMENT SHEET #4

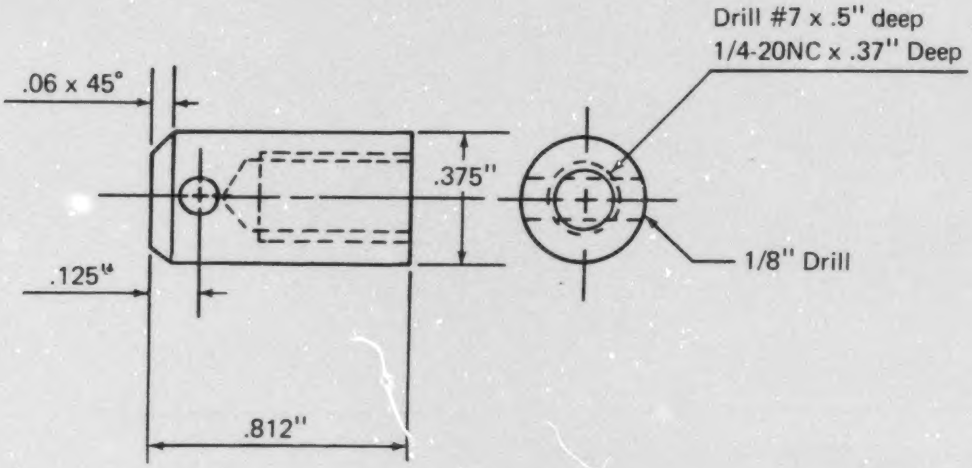
B. After doing the first run for the part below, you find that the 0.125" slot in the 1.5" diameter is 1.793" from the ¼" chamfered face. What offset is required?

Offset ____________________


1/8" x 45°
2" Diameter
1/8" x 45°
1/16" x 45°
1.5" Diameter
1/4" x 45°
.125"
.125"
.1856"
2 1/2"
1.264"
.118"
.072"
1 3/4"
1.500"
2 1/8"
4.000"

C. When the #7 drill is removed and the bore is inspected on the part below, you discover that the bore is not centered on the diameter. The actual hole center is 0.178" from the top surface when the part is aligned as shown in the print. What action is required?

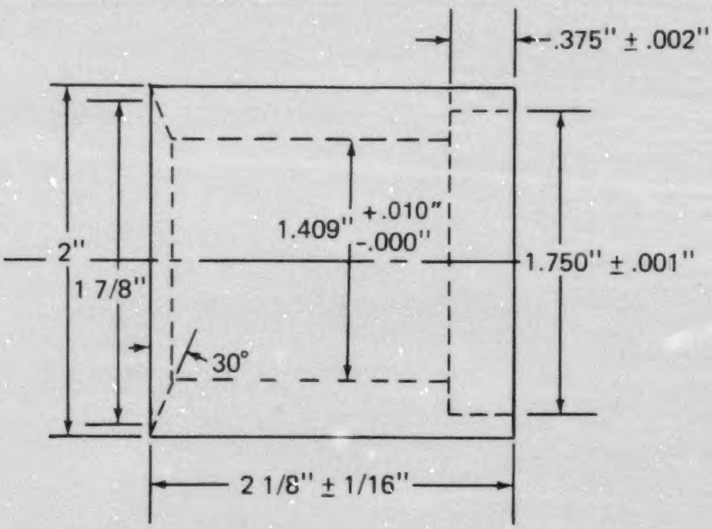
Offset ____________________


Drill #7 x .5" deep
1/4-20NC x .37" Deep
.06 x 45°
.375"
1/8" Drill
.125"
.812"

ASSIGNMENT SHEET #4

D. During the test run of the program for the part below, the boring bar travels 0.370" for the movement that is supposed to cut the 1.750" bore. What offset is required?

Offset ____________________


.375" ± .002"
2"
1 7/8"
1.409" +.010" -.000"
1.750" ± .001"
30°
2 1/8" ± 1/16"

E. The test run for the part in D also showed that the diameter of the 1.409" bore would actually be 1.415". What offset is required?

Offset ____________________

SET UP MACHINE AND TEST RUN PROGRAM
UNIT III

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

A. Flanged bushing

B. 12345

C. Cast iron

D. 100

E. No

F. 0.10 hours

G. $2\,{}^{9}/_{64}$

H. SM-004

I. 0000

J. 0.125 hours

Assignment Sheet #2 — Evaluated to the satisfaction of the instructor

Assignment Sheet #3 — Evaluated to the satisfaction of the instructor

Assignment Sheet #4

A. X − 0.003"

B. Z + 0.043"

C. X + 0.0095"

D. X + 0.005"

E. None (the bore is within tolerance)

SET UP MACHINE AND TEST RUN PROGRAM
UNIT III

JOB SHEET #1 — PREPARE A WORK STATION FOR PRODUCTION

I. Equipment and materials

   A. CNC lathe

   B. Work order

   C. Setup sheet

   D. Tools and materials indicated on work order and setup sheet

   E. Shop towels

   F. Standard sets of tools and inspection equipment for lathe operations

II. Procedure

   A. Study work order and setup sheet

   B. Clean unneeded tools and equipment and work area

   C. Pick up tools and equipment needed for next job, return unneeded tools from previous job

   D. Perform quick inspection and preventive maintenance after extended machine use

   E. Remove chips from work area

   F. Check to see that all tools are sharp and in good condition

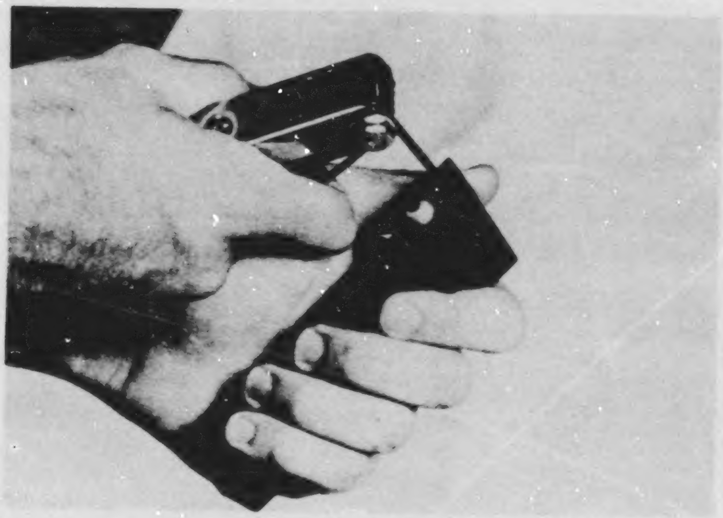
   G. Check to see that tool holders are in good condition

JOB SHEET #1

H. Load inserts into tool holders

1. Loosen clamp and pin on holder (Figure 8)

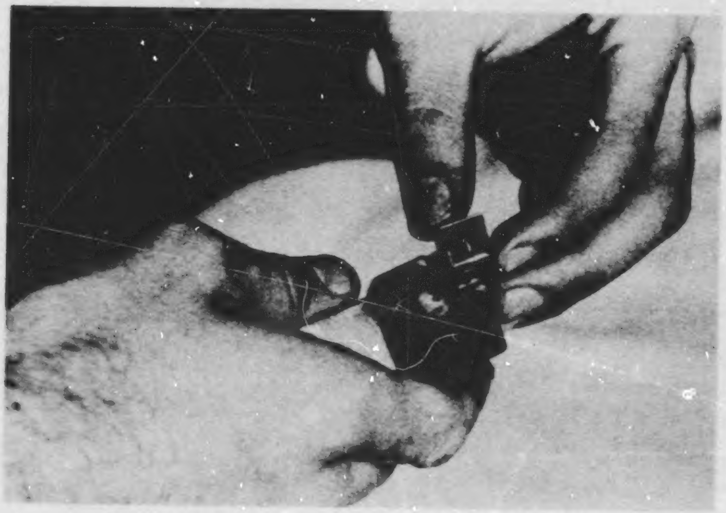
FIGURE 8



2. Clean pocket

3. Lay insert into pocket (Figure 9)

FIGURE 9



JOB SHEET #1

4. Tighten pin until snug

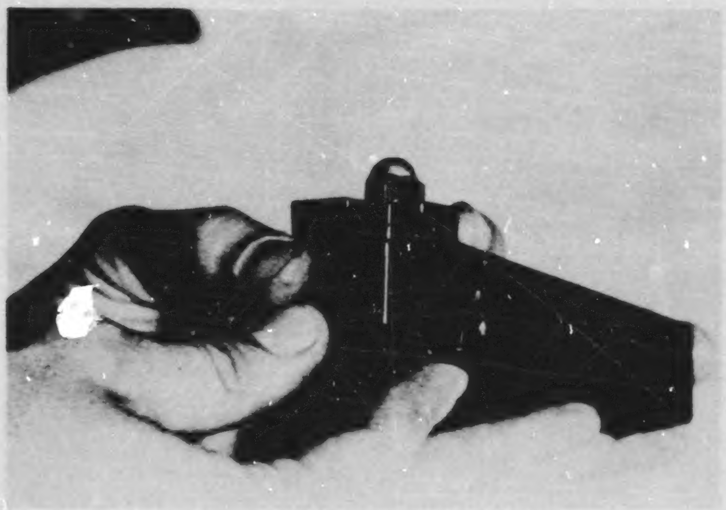
   (CAUTION: Do not over tighten.)

5. Tighten top clamp until snug

   (CAUTION: Do not over tighten.)

6. Check to see that insert is properly set in pocket and is flat against bottom shim (Figure 10)

FIGURE 10



I. Load drills, taps, and reamers into collet holders

   1. Loosen cap on holder (Figure 11)

FIGURE 11

JOB SHEET #1

2. Remove collet and store properly if replacement is required
3. Snap required collet into cap
4. Insert tool into collet, allowing proper tool extension from collet (Figure 12)

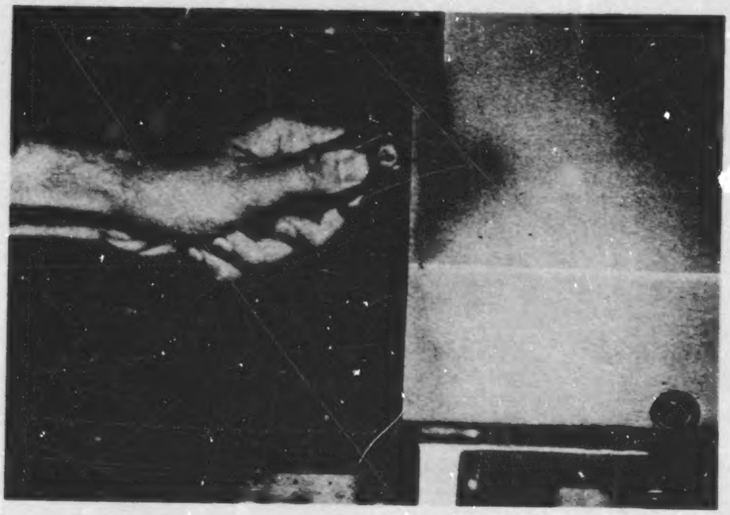
FIGURE 12

5. Place tool and collet assembly in holder and tighten cap

J. Set up boring bars and collet holders on machine

1. Loosen set screw in machine bushing (Figure 13)

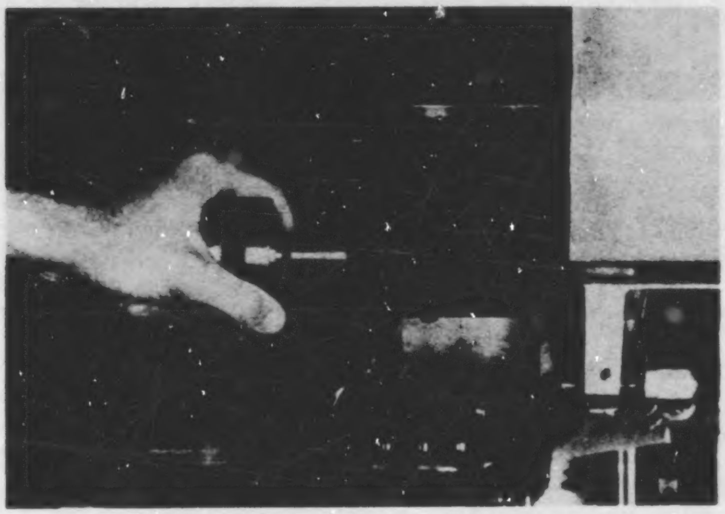
FIGURE 13



JOB SHEET #1

2. Clean inside of bushing and outside of tool holder
3. Slide holder into bushing with flat side aligned to set screw (Figure 14)

FIGURE 14



4. Adjust holder to correct length and tighten set screw to prevent holder from slipping

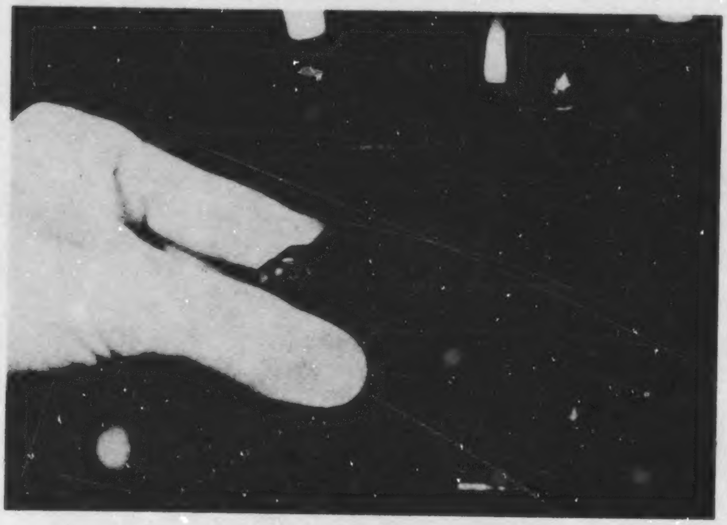
K. Set up outside diameter tool holders on machine

1. Loosen set screws on tool block and remove tool holder
2. Clean dirt and chips from tool holder and block
3. Install tool in holder

JOB SHEET #1

4. Place holder into block with end and back side of holder firmly against block (Figure 15)

FIGURE 15



5. Tighten set screws

L. Check all tools

1. Be sure tools are tight and properly installed

2. Verify that all tools are in the correct tool station

3. Check that inside diameter tools are properly extended

M. Continue with next required procedure

SET UP MACHINE AND TEST RUN PROGRAM
UNIT III

JOB SHEET #2 — SET UP JAWS

I. Equipment and materials

  A. CNC lathe

  B. Operator's manual

  C. Work order

  D. Set up sheet

  E. Various types of jaws

  F. Chucking piece

  (NOTE: Soft jaws can be bored for use in later projects by using SAE 4140 hot rolled steel stock, 1 1/4" diameter and 3 7/8" in length.)

  G. Shop towels

  H. Boring bar to suit jaw size

  I. Standard sets of tools and inspection equipment for lathe operations

II. Procedure

  A. Study work order and setup sheet

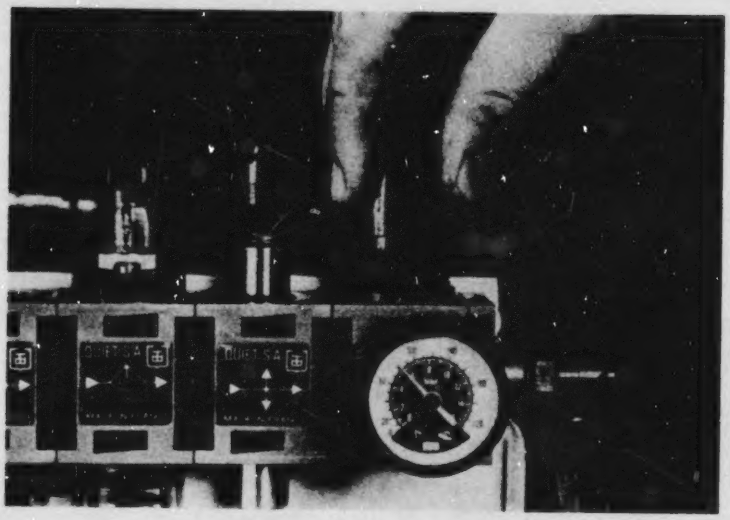
  B. Select chuck mode by setting chuck mode selector for internal or external application

JOB SHEET #2

C. Set chuck pressure

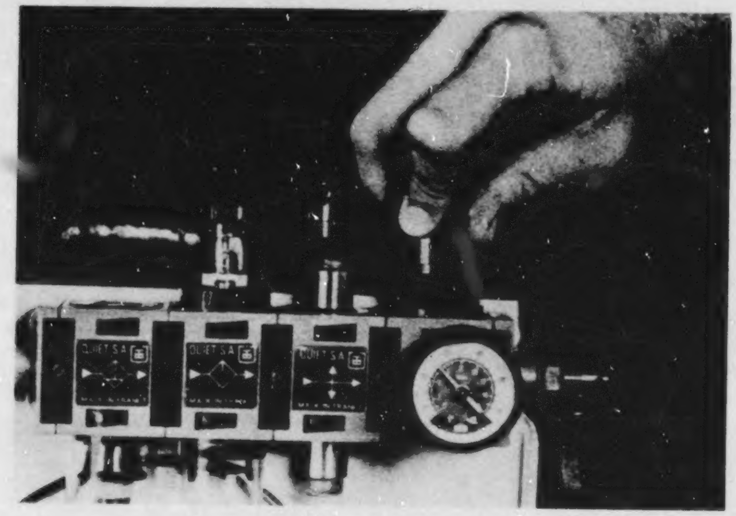
1. Lift selector knob (Figure 16)

FIGURE 16



2. Adjust to required pressure by turning selector knob (Figure 17)

FIGURE 17



(NOTE: The chuck mode and pressure are rarely changed in production machining, but occasionally such adjustments are necessary and may be specified on work orders or setup sheets.)

JOB SHEET #2

D. Bore soft jaws

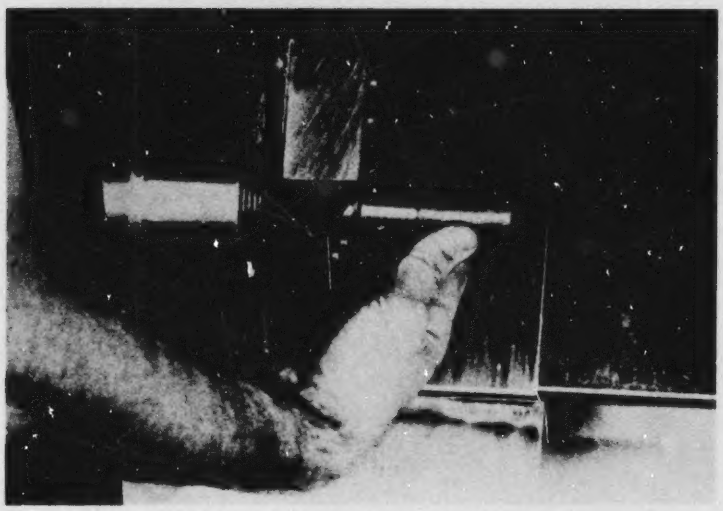
(NOTE: Boring soft jaws is a good exercise to use as your initial machining procedure on the CNC lathe. Use the chucking piece called for in the equipment list as the part to be chucked.)

1. Remove hard jaws if necessary

2. Attach soft jaws so that the part will not fit into the jaws when the chuck is closed (Figure 18)

   (NOTE: If jaws have been installed previously and numbered, match jaw and chuck numbers.)

FIGURE 18



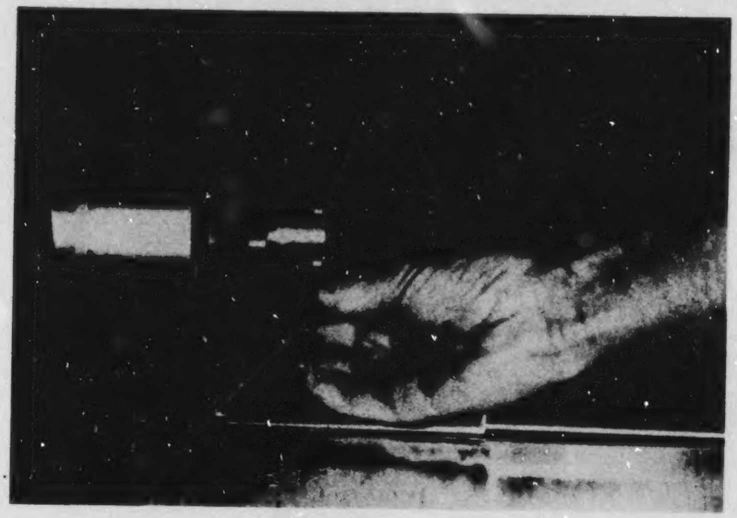
3. Tighten jaws securely

4. Select a spacer disc that will hold the jaws 0.050" to 0.100" smaller than the part to be chucked

JOB SHEET #2

5. Open the chuck and place the disc into the jaws approximately 1/4" deeper than the required bore (Figure 19)

FIGURE 19

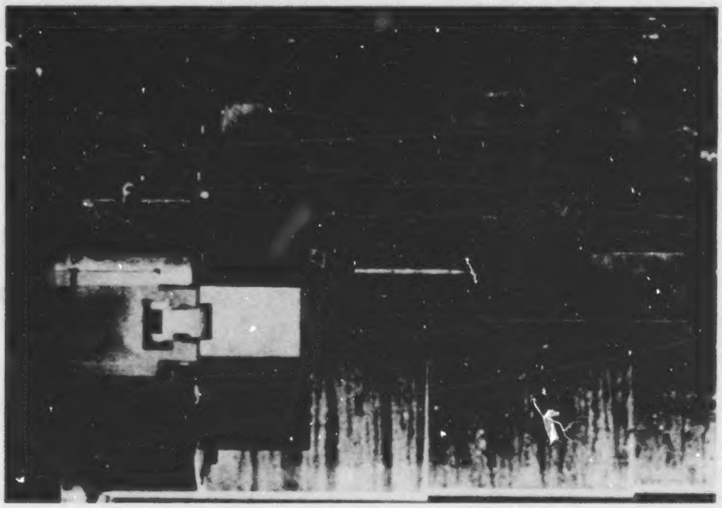


6. Close the jaws on the disc
7. Install the largest boring and grooving tools that will fit into the bore
8. Adjust length of tools as short as possible and tighten securely
9. Power up machine and control
10. Index to boring bar

JOB SHEET #2

11. Jog Z axis to within 0.010-0.020" of face of jaw using joystick and feed override switch to regulate travel rate (Figure 20)

FIGURE 20



12. Reset W register to zero

    a. Press *POS* key

    b. Press either *PAGE* key until U and W page is displayed

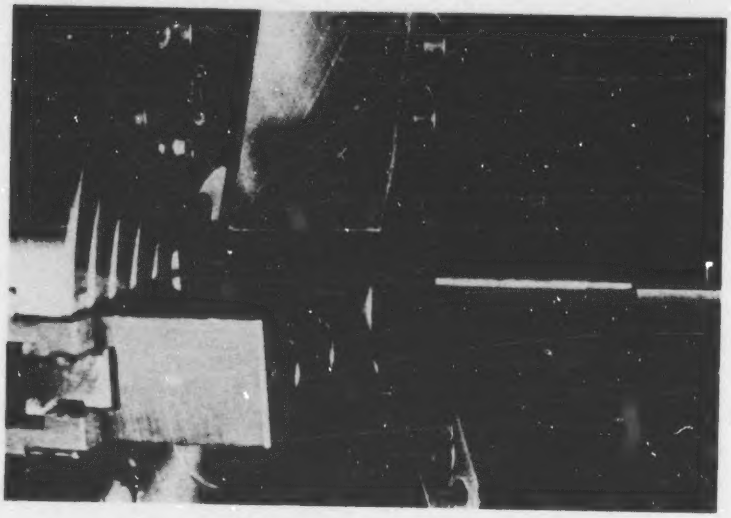
    c. Press *W* key on keypad

    d. Press *CAN* key

JOB SHEET #2

13. Move boring tool inside of jaws and position against center of one jaw (Figure 21)

FIGURE 21



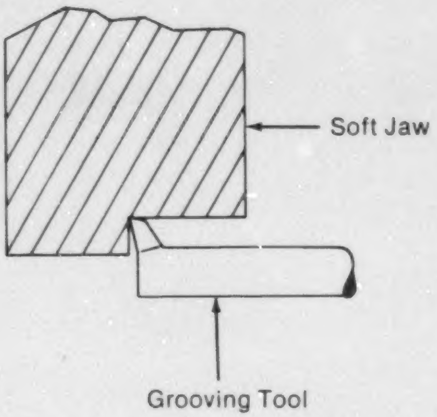
14. Reset U register to zero
    a. Press *POS* key
    b. Press either *PAGE* key until U and W page is displayed
    c. Press *U* key on keypad
    d. Press *CAN* key
15. Reposition tool approximately 0.100" from jaws in Z axis and in position to take a 0.050" depth of cut
16. Start spindle using required cutting speed

    (NOTE: See Unit II, Job Sheet #1 if you need to review this procedure.)
17. Feed tool in to correct depth
18. Feed tool away from machined surface and remove from bore
19. Stop spindle
20. Repeat steps 16 through 19 as required until the bore is 0.001" to 0.003" larger than the diameter of the part

JOB SHEET #2

21. Home X axis and then home Z axis
22. Measure depth of bore
23. Index grooving tool to within 0.010-0.020" of jaws and jog inside bore
24. Reset U and W registers
25. Position Z axis to make a slight cut across the back face of the bore (Figure 22)

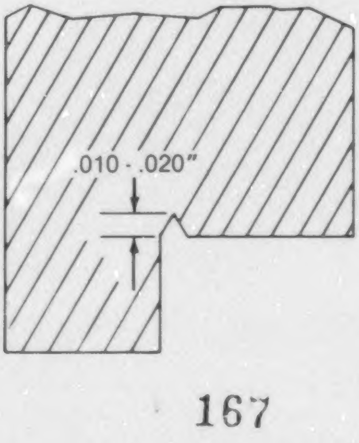
FIGURE 22



26. Start spindle
27. Feed the grooving tool along the X axis until a 0.030" to 0.040" groove is cut in the back of the jaws (Figure 23)

    (NOTE: The groove allows a good seating of the workpiece by providing room for burrs and jagged edges produced during machining.)

FIGURE 23

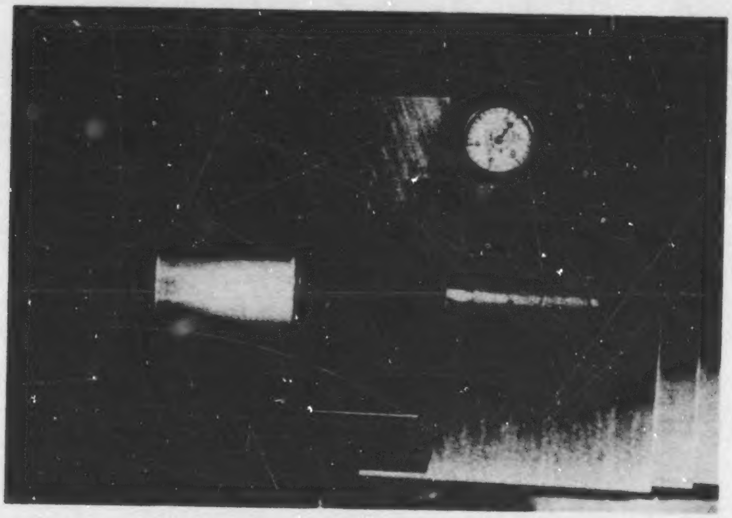


JOB SHEET #2

28. Clear tool from bore and retract
29. Stop spindle
30. Home X axis and then home Z axis
31. Use a small file to deburr the edges of the jaws
32. Wipe jaws clean and remove disc
33. Chuck on part

    (CAUTION: Keep fingers clear of jaws.)
34. Use dial indicator to check runout (Figure 24)

FIGURE 24



(NOTE: You should be able to use the CNC lathe to bore the jaws so that the runout is within 0.001". If your bore failed to meet this tolerance, discuss additional practice requirements with your instructor.)

35. Number jaws for future installations

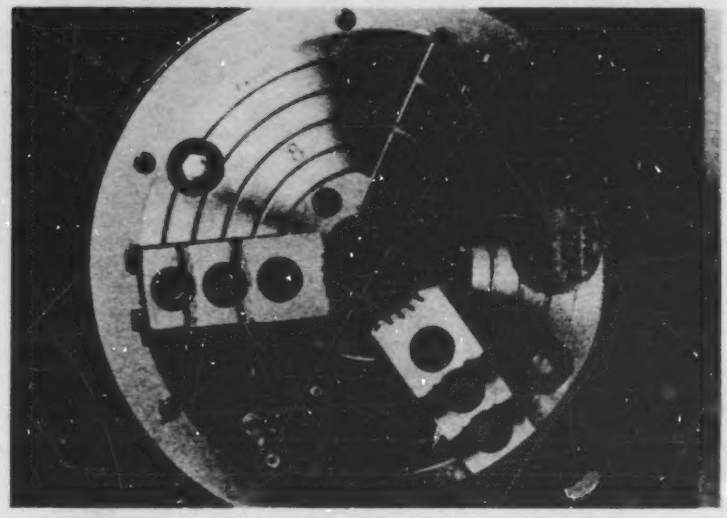
E. Install hard jaws

1. Remove jaws if required
2. Remove bolts from jaws
3. Set bolts in jaws to be installed
4. Place jaws on chuck and tighten slightly so that area between jaws is slightly less than diameter of part to be chucked

JOB SHEET #2

5. Check to see that jaws tighten evenly (Figure 25)

FIGURE 25



6. Close chuck and check to see that part will not fit into jaws

   (NOTE: If the part does fit into the jaws, loosen jaws and repeat steps 4 through 6 to reposition jaws so that part will not fit into them.)

7. Open chuck and check to see that part will fit into jaws

   (NOTE: If the part does not fit into the jaws, loosen jaws and repeat steps 4 through 7 to reposition jaws so that part will fit into them at step 7, but not at step 6.)

8. Chuck part securely in jaws

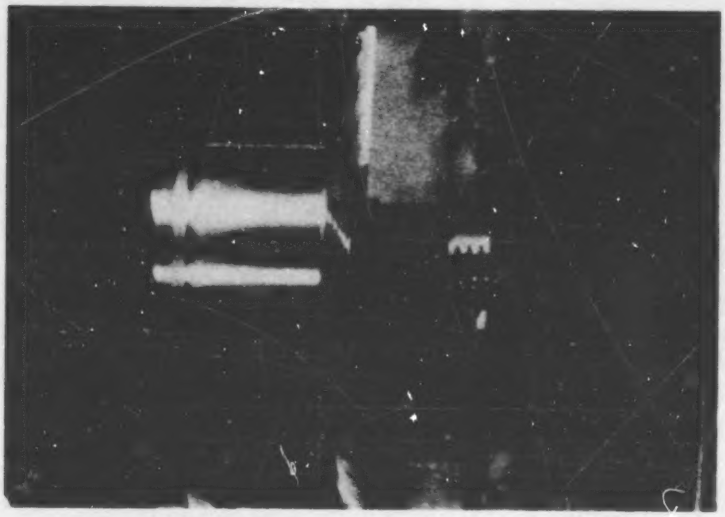
   (NOTE: The jaws should grip the part at the middle of the jaw stroke.)

9. Set spindle speed to 200 rpm and start spindle

JOB SHEET #2

10. Check to see that jaws are running true (Figure 26)

FIGURE 26



11. Turn off spindle

F. Put away tools and materials or continue with next procedure

SET UP MACHINE AND TEST RUN PROGRAM
UNIT III

JOB SHEET #3 — LOAD PROGRAM

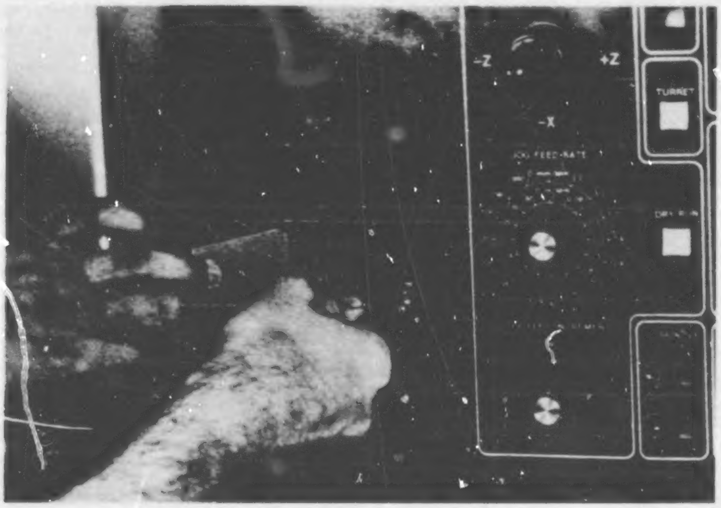
I. Equipment and materials

- A. CNC lathe
- B. Operator's manual for lathe, control unit, and program loading equipment
- C. Work order and setup sheet
- D. Programs and tapes to be loaded
- E. Shop towels

II. Procedure

- A. Load program using NC tape or bubble cassette
    1. Power up machine and control
    2. Connect suitable portable tape or cassette reader to machine port (Figure 27)

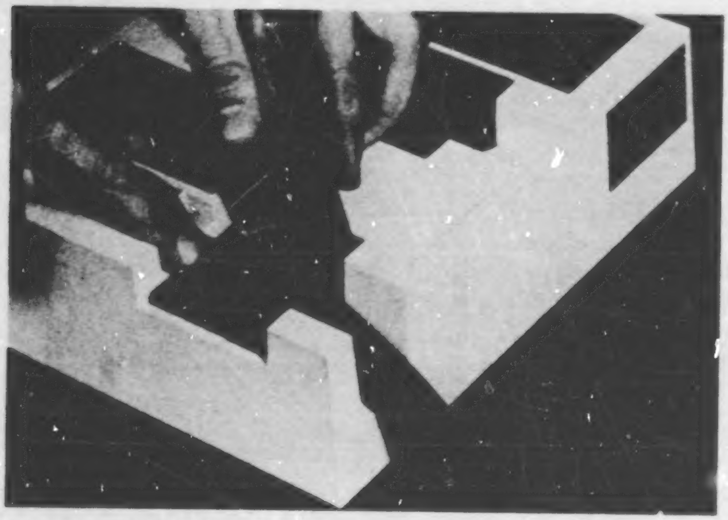
FIGURE 27



JOB SHEET #3

3. Plug portable reader into suitable electrical outlet
4. Load tape or cassette into reader (Figure 28)

FIGURE 28



5. Set mode select switch to *EDIT*
6. Press *PRGRM* key
7. Turn machine enable key switch to *ON*
8. Type in program number

   (NOTE: The program number should be an *O* followed by four digits. If you make a mistake while using the keypad, press the *CAN* button prior to pressing the *INPUT* button. If you discover the incorrect input after you have pressed the *INPUT* button, press the *RESET* button and begin the procedure over at the required step.)

9. Press *INPUT* key
10. Press *READ* button on reader
11. Allow tape or cassette to feed completely
12. Remove tape or cassette and store properly
13. Disconnect reader from machine port

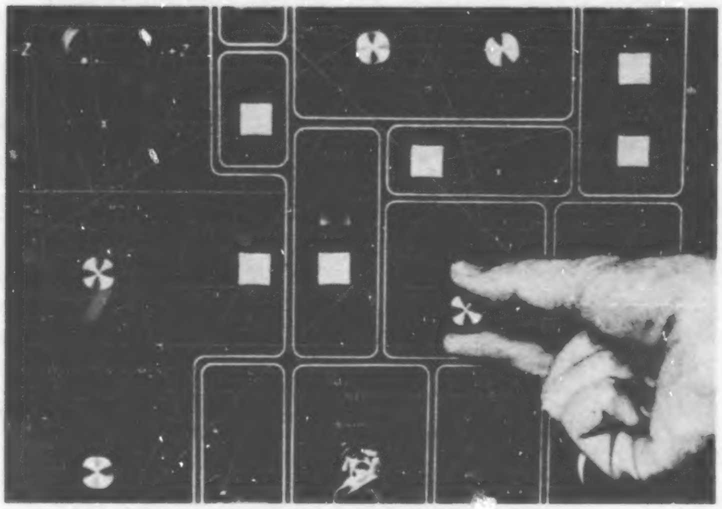
JOB SHEET #3

14. Disconnect reader from power source
15. Press *RESET* key
16. Return reader to storage

B. Load program by MDI

1. Power up machine and control
2. Place mode select switch in *EDIT* (Figure 29)

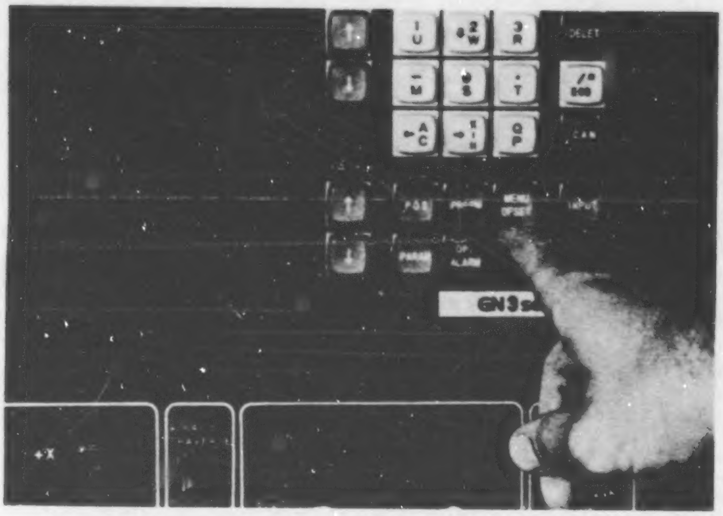
FIGURE 29



JOB SHEET #3

3. Press *PRGRM* key (Figure 30)

FIGURE 30


DELET
CAN
INPUT
GN3
+X

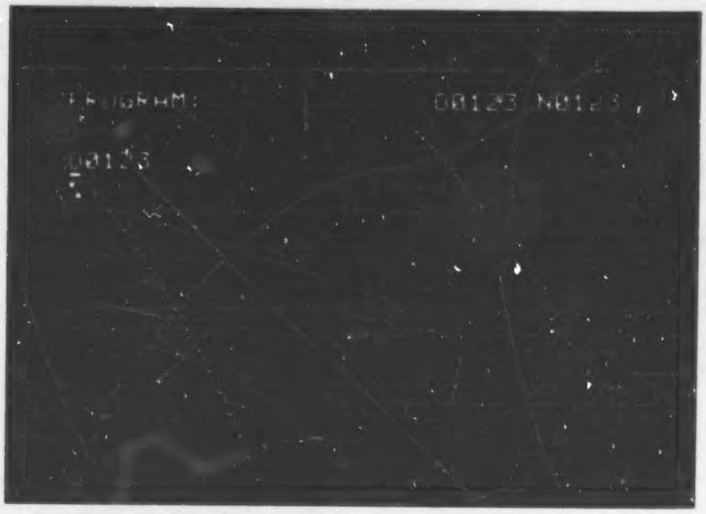
JOB SHEET #3

4. Press O key, program number, and then *INSERT* key

   EXAMPLE: O 1234 INSERT

   (NOTE: The CRT should display the program number in the top left-hand corner of the screen; see Figure 31.)

FIGURE 31



```
PROGRAM:                    O0123 N0123

O0123
```

5. Press *EOB* key, then *INSERT* key

6. Type in each word of the program one word at a time and press *INSERT* key after each word

JOB SHEET #3

7. Press the *EOB* key and *INSERT* key after each block has been input

   (NOTE: This will print an asterisk [*] which tells the control the next information is one line down; see Figure 32)

FIGURE 32

JOB SHEET #3

8. Turn mode select switch to *MDI*

   (NOTE: Any position other than *EDIT* may be used.)

C. Load program using download procedure

1. Power up machine and control
2. Power up external computer
3. Plug external computer output cable into machine port

   (NOTE: An adapter may be required.)
4. Prepare external computer for output
5. Set mode select switch to *EDIT*
6. Press *PRGRM* key
7. Turn machine enable key switch to *ON*
8. Type in program number

   (NOTE: The program number should be a letter *O* followed by four digits.)
9. Press *INPUT* key
10. Wait for external computer to signal system prompt
11. Disconnect output cable from machine port
12. Press *RESET* key
13. Return external computer to required operation

D. Continue to next required procedure

SET UP MACHINE AND TEST RUN PROGRAM
UNIT III

JOB SHEET #4 — MOVE U AND W SLIDES TO PROGRAM HOME POSITION

I. Equipment and materials

- A. CNC lathe
- B. Operator's manual
- C. Work order and setup sheet
- D. Shop towels

II. Procedure to jog

- A. Power up machine and control
- B. Home both axes
- C. Reset U and W registers to zero
- D. Consult setup sheet for distances from machine home to the program home position
- E. Move joystick to the *Z*- position and hold until amount required shows on *W* register
- F. If necessary, move joystick to the *X*- position and hold until the amount required shows on the *U* register

  (NOTE: It is generally not necessary to set the *U* point because the X axis will generally start at the X home position.)
- G. Press *U* key
- H. Press *CAN* key
- I. Press *W* key
- J. Press *CAN* key
- K. Continue with next required procedure

III. Procedure using MDI

- A. Power up machine and control
- B. Home both axes

JOB SHEET #4

C. Reset *U* and *W* registers to zero

D. Set mode select switch to *MDI*

E. Press *PRGRM* key

F. Consult setup sheet for *U* and *W* distances

G. Close front safety door

H. Key in *G00* and press *INPUT* key

I. Key in *U* and required distance; press *INPUT* key

(NOTE: The *U* and *W* distances will negative.)

J. Key in *W* and required distance; press *INPUT* key

K. Press *CYCLE START* button

L. Continue with next required procedure

SET UP MACHINE AND TEST RUN PROGRAM
UNIT III

JOB SHEET #5 — DETERMINE INITIAL OFFSETS AND STORE IN CONTROL

I. Equipment and materials

A. CNC lathe

B. Operator's manual

C. Work order and setup sheet

D. Shop towels

E. Standard sets of tools and inspection equipment for lathe operations

II. Procedure

A. Power up machine and control

B. Consult setup sheet for offset values of tools

C. Move U and W slides to program home position

D. Set mode select switch to *MDI*

E. Press *PRGRM* key

F. Press either *PAGE* key until MDI page is displayed

G. Key in G50, and press the *INPUT* key

(NOTE: This manually sets a G50 code, resetting the X and Z axes so that a tool point position may be defined.)

H. Press *X* key followed by the G50 X value for one tool and then press the *INPUT* key

(NOTE: This loads the X offset value for the first tool in the memory.)

I. Press the *Z* key followed by the G50 Z value for the tool and then press the *INPUT* key

(NOTE: This loads the Z offset value, thus identifying the coordinates of the starting point for that tool.)

J. Press the *CYCLE START* button

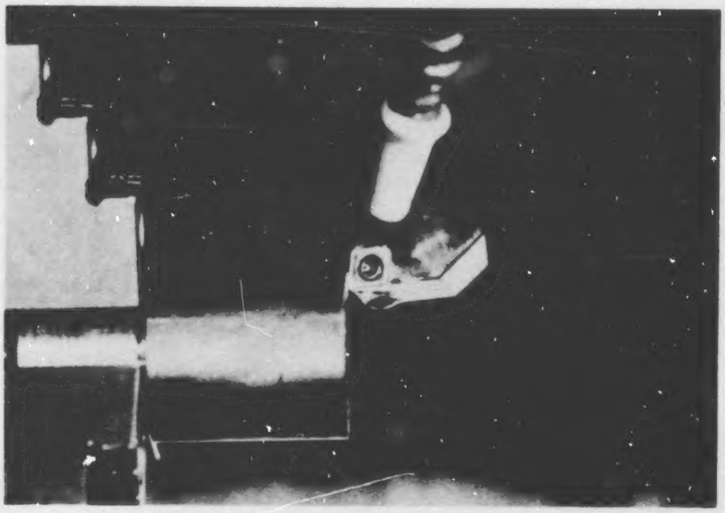
K. Set the spindle at 200-500 rpm and start it

JOB SHEET #5

L. Index to the tool whose G50 values have been loaded

M. Move the X and Z axes until tool touches the face of the workpiece (Figure 33)

FIGURE 33



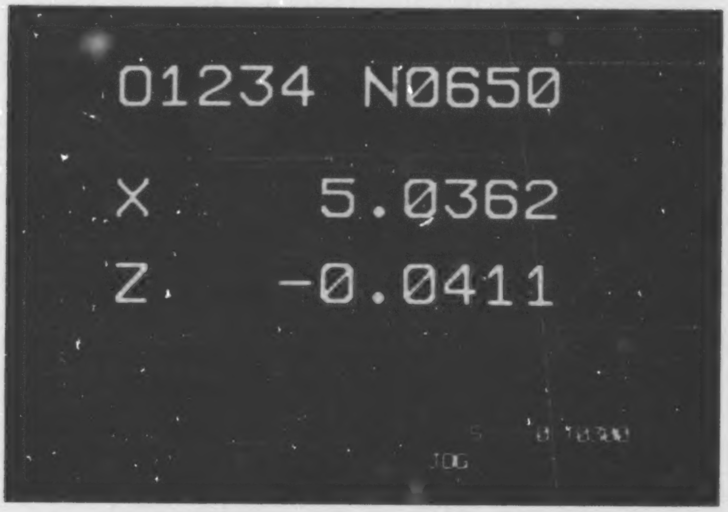
N. Press *POS* key

O. Press either *PAGE* key to display X and Z page

P. Write down the Z register value (Figure 34)

(NOTE: The Z register value is the required Z offset for this tool. Be sure to indicate whether the value is + or −.)

FIGURE 34



```
01234 N0650

X      5.0362
Z     -0.0411

                S    0 T0300
      JOG
```

JOB SHEET #5

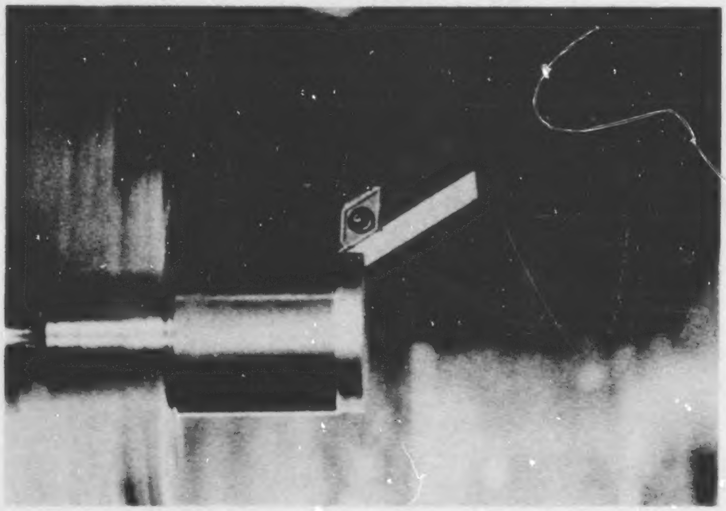
Q. Position tool to take a slight turn cut at an even diameter

EXAMPLE: If using 2 1/2", set the tool to cut to 2.400" not to an odd value such as 2.4167"

R. Start coolant flow

S. Manually make the cut, making it long enough so that an accurate measurement may be taken (Figure 35), and then stop coolant flow

FIGURE 35



T. Record the X and Z register values

U. Move the tool back to the setup position

V. Check the actual size of the part where the cut has been made

W. Calculate the X offset and write down the value

(NOTE: The program size is determined from the X register value.)

X. Measure the length of the cut

Y. Calculate the Z offset and write down the value

(NOTE: The program size is determined from the Z register value.)

Z. Repeat procedure to determine offset values for other tools

(NOTE: Use an indicator to center drills and reamers.)

JOB SHEET #5

AA. Load calculated offset values

1. Press *MENU OFFSET* key
2. Press either *PAGE* key to display tools 1 through 8 page
3. Press *CURSOR* button until cursor is beside tool number to be loaded
4. Key in the X offset value and press the *INPUT* key

   (NOTE: Be sure to indicate negative values.)
5. Key in the Z offset value and press the *INPUT* key.

   (NOTE: Be sure to indicate negative values.)
6. Repeat steps 3 through 5 for other tools

BB. Continue with next required procedure

SET UP MACHINE AND TEST RUN PROGRAM
UNIT III

JOB SHEET #6 — TEST RUN PROGRAM

I. Equipment and materials

- A. CNC lathe
- B. Operator's manual
- C. Work order and setup sheet
- D. Required tools
- E. Program (tape, written program, etc. as required)

II. Procedure

- A. Prepare work station for production
- B. Power up machine and control
- C. Set up jaws
- D. Load program
- E. Move U and W slides to program home position
- F. Identify initial offsets and store in control
- G. Remove part from chuck and close chuck
- H. Set mode select switch to *EDIT*
- I. Press *PRGRM* key
- J. Press *RESET* key
- K. Set mode select switch to *AUTO*
- L. Close guard door
- M. Press yellow *SINGLE BLOCK* button to illuminate light

  (CAUTION: When test running a program, keep your hand by the E-stop button in case you need to stop the machine to prevent damage in the event of program errors.)

- N. Press *CYCLE START* button

  (NOTE: Once the *CYCLE START* button has been pressed, the first block of the program will be loaded. The operator must press the button again for each program block to be loaded.)

JOB SHEET #6

O. Press *POS* key

P. Press either *PAGE* key to display page with four smaller displays

Q. Monitor program execution

(NOTE: Try to envision the actual turning operation. Watch the tool movements and the display screen. Pay special attention to the *DISTANCE TO GO* readings on the screen. This informs the operator of how much further travel is required for that portion of the program. Make sure that adequate clearance exists for all movements. For example if the *DISTANCE TO GO* display shows that the tool will travel another 1.625" while the tool is only about ½" from the chuck, stop the machine by pressing the black *FEED HOLD* button or the red *STOP* button. The procedure will continue from that point when the *FEED HOLD* button is twisted and released. However, if the *STOP* button was depressed, the tool must be returned to the setup position and the program rerun.)

R. Run entire program and tooling movements

1. Note any errors in program
2. Edit program or change offsets if required

   (NOTE: Changes should be made as they are detected. Otherwise, an accurate assessment of the program cannot be made because changes in offsets and program edits will affect other movements. For example, if a rough cut does not touch the part, you must change the offset as required before you can determine if the second pass is correct.)

SET UP MACHINE AND TEST RUN PROGRAM
UNIT III

JOB SHEET #7 — EDIT PROGRAM FOR FIRST RUN

I. Equipment and materials

  A. CNC lathe with program loaded

  B. Operator's manual

  C. Work order and setup sheet

  D. Required tools, preset according to setup sheet

  E. Notes on program errors

II. Procedure

  A. Set mode select switch to EDIT

  B. Press *PRGRM* key

  C. Press *RESET* key

  D. Search to program block requiring edit

    1. Key in letter address N and block number and press *INPUT* key

    2. Press *CURSOR* down key

    (NOTE: Cursor will appear at beginning of block specified.)

    3. Press the *CURSOR* down key until cursor is under letter address requiring change

  E. Check for the proper G code format for the line requiring change

  (NOTE: The formats will be listed at the bottom of the display for that page.)

  F. Press the keypad letter that corresponds to the address requiring change

  G. Key in the information that should follow the letter address

  H. Press the red *ALTER* key

  (NOTE: This action will change the program to the information that you have input.)

JOB SHEET #7

I. To erase a letter address, position the cursor under the address to be erased and press the red *DELET* button

J. To insert information, place the cursor to the left of the position where the information is to be inserted

1. Type in the new information

2. Press the red *INSRT* key

   (NOTE: The new information will appear to the right of the word indicated by the cursor.)

K. Continue to next required procedure

SET UP MACHINE AND TEST RUN PROGRAM
UNIT III

TEST

NAME ______________________________ SCORE ______________

1. Match terms associated with setting up the machine to their correct definitions. Write the correct numbers in the blanks.

_____a. Printed copy of all information contained on an NC tape

_____b. Carbide cutting tool that can be quickly inserted into or removed from a special holder

_____c. Hardened, serrated chuck jaws

_____d. To make changes in a program or in the program stored in the control unit memory

_____e. Chuck jaws made of a soft material so that they may be machined to fit a particular part

_____f. Document provided by the programmer to inform CNC turning technician of tools to be used and the position of those tools

_____g. Holding device available in various diameters for different sizes of workpieces or straight-shank tools

_____h. One-inch wide paper tape punched with program information

_____i. Difference between the size of a part according to the program and the actual size machined

_____j. Tools and holding devices required for a set-up

_____k. To prepare the machine and control unit with the necessary tooling and programming required for a particular production

_____l. Operation of a CNC program with all tooling but no workpiece

_____m. Device for holding cutting tools

1. Offset value
2. Edit
3. Test run
4. NC readout
5. NC tape
6. Setup sheet
7. Soft jaws
8. Set up
9. Carbide insert
10. Tool holder
11. Tooling
12. Collet
13. Hard jaws

TEST

2. Match G and M codes associated with setup to their correct functions. Write the correct numbers in the blanks.

______a. Causes all machine movements to be made in rapid traverse mode

______b. Causes machine to follow straight line between two specified points

______c. Causes the machine and control unit to stop all activities and processing until the *CYCLE START* button is pressed

______d. Presets axis registers and limits maximum spindle speed; used to define the location of a tool point

______e. Signals end of program and causes machine to reset to control status at beginning of program

______f. Causes machine to follow clockwise arc between two specified points

______g. Causes coolant flow to begin

______h. Causes the machine to follow a counterclockwise arc between two specific points

______i. Stops coolant flow

1. M30
2. G01
3. M08
4. G00
5. G50
6. M00
7. G03
8. G02
9. M09

3. Select from a list correct guidelines for setup. Place an "X" in the blank before each correct answer.

______a. Clean machine and work area before starting any new job

______b. Study work order and setup sheet to become familiar with workpiece design and required operations

______c. Pick up inspection tools, then cutting tools, and finally finishing tools as you begin each process

______d. Review setup sheet and install tooling properly

______e. Install tools loosely to allow quick setup changes

______f. Note any changes made to tooling setup on work order so that program can be corrected

TEST

_____g. Check setup sheet prior to returning tools from previous job to see if any of them may be used for the next job

_____h. Obtain necessary tools, equipment, and materials

_____i. Perform quick preventive maintenance inspection after extended machine operation

4. Name five items of information that might be found on a work order.

    a. ____________________

    b. ____________________

    c. ____________________

    d. ____________________

    e. ____________________

5. Name three items of information that might be found on a setup sheet.

    a. ____________________

    b. ____________________

    c. ____________________

6. Match jaws and collets to their correct uses. Write the correct numbers in the blanks.

_____a. Used to hold symmetrical workpieces on center

_____b. Used to hold small semifinished or finished parts so that additional symmetrical, on-center operations can be performed

_____c. Used to hold irregular and nonsymmetrical workpieces

_____d. Used to hold regular or irregular workpieces on- or off-center

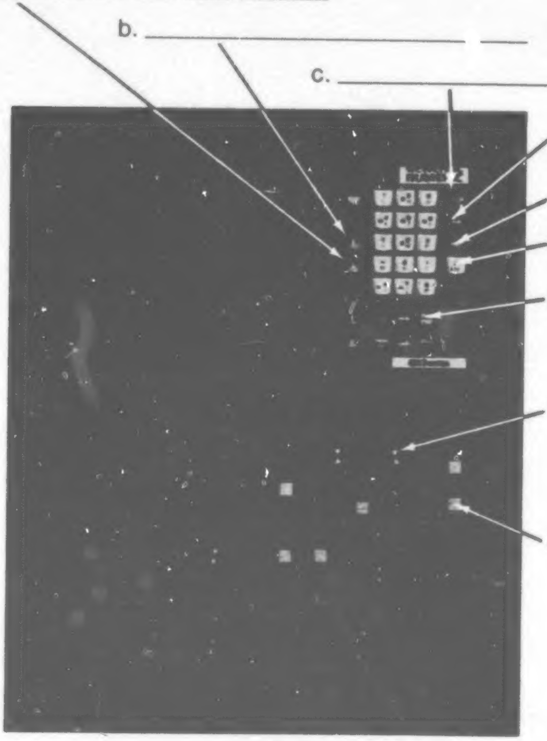
_____e. Machined to fit workpieces to protect machined surfaces or to allow concentric machining

1. Soft jaws
2. Two-jaw chuck
3. Three-jaw chuck
4. Four-jaw chuck
5. Collet

TEST

7. Identify controls used to set up machine and test run program. Write the correct names from the list below in the blanks provided.

Single block button
Alter key
Feed rate override switch
Cursor up key
End of block key
Insert key
Cursor down key
Menu offset key
Delete key



a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

i. ______________________________

TEST

8. Match controls to set up machine and test run program to their correct functions. Write the numbers of the controls listed on the right beside their correct functions.

______a. Moves cursor forward on CRT display one line for each time the button is pushed

______b. Moves cursor back on CRT display one line for each time the button is pushed

______c. Allows operator to change stored information to data input on keypad following letter address

______d. Allows operator to insert information to the right of a point marked by the cursor

______e. Allows operator to delete information at a point marked by the cursor

______f. Allows operator to indicate end of data block when keying in data

______g. Allows operator to input tool offset values

______h. Allows operator to manually set feed rate at a percentage of the programmed feed rate

______i. Allows operator to direct machine to execute only one block of a program at a time and stop

1. Insert key
2. Single block button
3. Menu offset key
4. End of block
5. Feed rate override switch
6. Cursor up key
7. Alter key
8. Delete key
9. Cursor down key

9. State the functions of mode select switch positions used to set up machine and test run program. Write the functions in the blanks provided.

a. EDIT — ____

____

b. AUTO — ____

____

c. STEP — ____

____

TEST

10. Describe methods of loading programs into a control unit.

a. NC tape — ______________________________

____

b. MDI — ______________________________

____

c. Bubble cassette — ______________________________

____

d. Downloading from another computer — ______________________

____

11. Match components of program information to their correct descriptions. Write the numbers of the components listed on the right beside their correct descriptions.

_____a. Four-digit number and the letter *O* used to identify a program

_____b. Four-digit number and the letter *N* used to identify a portion of a program

_____c. Minimum amount of data that is necessary to command the machine to perform a function either internally or externally

_____d. Minimum unit of a block; consists of a letter address and the numerical data

_____e. Letter portion of a word

_____f. Numerical portion of a word, including the sign

1. Block
2. Sequence number
3. Word
4. Data
5. Program number
6. Address

TEST

12. Given the following information, calculate offset values.

    a. A blueprint calls for a part to have a diameter of 1.500". The machined part's actual diameter is 1.487". What offset is required?

    Offset = ____________________

    b. The shoulder on a bushing is 0.387" wide. The blueprint calls for a shoulder 0.380" ± 0.002". What offset is required?

    Offset = ____________________

(NOTE: Test questions 13 through 16 list the assignment sheets and job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

13. Interpret a work order.

14. Interpret a setup sheet.

15. Interpret CRT displays.

16. Demonstrate the ability to prepare a work station for production.

    a. Prepare a work station for production.

TEST

b. Set up jaws.

c. Load program.

d. Move U and W slides to program home position.

e. Determine initial offsets and store in control.

f. Test run program.

g. Edit program for first run.

SET UP MACHINE AND TEST RUN PROGRAM
UNIT III

ANSWERS TO TEST

1.	a.	4	f.	6	k.	8
	b.	9	g.	12	l.	3
	c.	13	h.	5	m.	10
	d.	2	i.	1		
	e.	7	j.	11		

2.	a.	4	f.	8
	b.	2	g.	3
	c.	6	h.	7
	d.	5	i.	9
	e.	1		

3. a, b, d, g, h, i

4. Answer should include any five of the following

    a. Name and number of part or job
    b. Work order number
    c. Page number if more than one page
    d. Part print
    e. Material specifications
    f. Required operations
    g. Number of parts required
    h. Program numbers
    i. Production deadline
    j. Authorization
    k. Standard times required for setup and production operations

ANSWERS TO TEST

5. Answer should include any three of the following
    a. Part and operation identification
    b. Tools required
    c. Tool positions
    d. Sequence of operations
    e. Special instructions to operator
    f. Program home position
    g. Programming information

6. a. 3
    b. 5
    c. 2
    d. 4
    e. 1

7. a. Cursor down key
    b. Cursor up key
    c. Alter key
    d. Insert key
    e. Delete key
    f. End of block key
    g. Menu offset key
    h. Feed rate override switch
    i. Single block button

8. a. 9
    b. 6
    c. 7
    d. 1
    e. 8
    f. 4
    g. 3
    h. 5
    i. 2

9. a. EDIT — Used to make changes to program stored in control
    b. AUTO — Used to allow machine operation by program commands

ANSWERS TO TEST

c. STEP — Used to move axes in short movements as determined by the step increment setting

10. a. NC tape — Data is stored on paper or mylar tape and loaded through a tape reader

b. MDI — Data is input through key pad by operator or set up person

c. Bubble cassette — Data is stored on a special cassette tape and loaded through a tape reader

d. Downloading from another computer — Data from one computer is transferred to another

11. a. 5 d. 3

b. 2 e. 6

c. 1 f. 4

12. a. X + 0.013″

b. Z + 0.007″

13. Evaluated to the satisfaction of the instructor

14. Evaluated to the satisfaction of the instructor

15. Evaluated to the satisfaction of the instructor

16. Performance skills evaluated to the satisfaction of the instructor

EVALUATE FIRST RUN
UNIT IV

UNIT OBJECTIVE

After completing this unit, the student should be able to evaluate a CNC lathe-produced part in terms of design requirements. The student will show this knowledge by completing assignment sheets and unit test with a minimum score of 85 percent and by producing a part within all tolerances on the second run.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with machining evaluation to their correct definitions.
2. Select from a list items to check during a visual inspection of first run.
3. Match blueprint symbols to their correct meanings.
4. Match inspection equipment to their correct descriptions.
5. Select from a list items to check during a dimensional inspection of first run.
6. Name three indications that program editing may be necessary.
7. List actions to take for setup flaws.
8. Read blueprint.
9. Calculate revised offset values.
10. Determine required program and setup changes.
11. Demonstrate the ability to
    a. Run first part.
    b. Evaluate first run.
    c. Edit program and change setup as required.
    d. Run and evaluate second part.

EVALUATE FIRST RUN
UNIT IV

INSTRUCTIONAL OVERVIEW

I. Unit contents

   A. Objective sheet

   B. Instructional overview (instructor copy)

   C. Instructional supplements (instructor copy)

   D. Information sheet

   E. Assignment sheets

      1. Assignment Sheet #1 — Read Blueprint

      2. Assignment Sheet #2 — Inspect Parts

      3. Assignment Sheet #3 — Calculate Revised Offset Values

      4. Assignment Sheet #4 — Determine Required Program and Setup Changes

   F. Answers to assignment sheets (instructor copy)

   G. Job sheets

      1. Job Sheet #1 — Run First Part

      2. Job Sheet #2 — Evaluate First Run

      3. Job Sheet #3 — Edit Program and Change Setup As Required

      4. Job Sheet #4 — Run and Evaluate Second Part

   H. Test

   I. Answers to test (instructor copy)

II. Suggested activities

   A. Review unit of instruction and plan method of presentation.

   B. Obtain materials necessary to supplement the unit.

   C. Make transparencies.

INSTRUCTIONAL OVERVIEW

D. Introduce unit to students.

SUGGESTIONS:

- Show students a good example and a bad example of the same part or two parts that are supposed to fit together which do not; emphasize the importance of part evaluation, pointing out how costly it would be to produce thousands of parts that are out of tolerance.
- Invite a quality control inspector from a manufacturing plant to discuss the inspection process and its importance.
- Show videotape "Run First Part," emphasizing the problems and part defects that may occur.

E. Provide students with unit of instruction.

F. Discuss unit and specific objectives; emphasize how the objectives are important in light of your introduction to this unit.

G. Discuss information sheet.

1. Use Section I of the information sheet to discuss terms associated with evaluation of the first run.

   SUGGESTIONS:

   - Emphasize the importance of communications in the evaluation of a part, which is based on the operator being able to understand a blueprint and the standards and tolerances listed on it.
   - Let the students try to describe parts or blueprint designs to each other without using the terms given; then do the exercise with the students using blueprint language.

2. Use Section II of the information sheet to discuss blueprint symbols.

   SUGGESTIONS:

   - Emphasize that the symbols are just another part of the language of blueprints.
   - Use Assignment Sheet #1 to reinforce the information presented.
   - Invite a draftsperson to discuss drafting with the class or take the class to a drafting studio.

     (NOTE: The students may be especially interested in computer-assisted design and how it relates to CNC machining.)

INSTRUCTIONAL OVERVIEW

3. Use Section III of the information sheet to discuss visual inspection of parts.

   SUGGESTIONS:

   - Show examples of the defects and chips covered in the information sheet.
   - Display a profilometer, V-block, and dial indicator; demonstrate their uses.
   - Have the students do Job Sheet #1 to produce their first part and allow them to study their first run as you discuss visual inspection.

4. Use Section IV of the information sheet to discuss dimensional inspections.

   SUGGESTIONS:

   - Demonstrate the use of equipment used in dimensional inspections.
   - Visit a shop and observe inspections being made.
   - Allow the students to study their first runs as you discuss dimensional inspections and demonstrate Job Sheet #2; have students do Job Sheet #2.
   - Allow the students to practice inspections by providing them with machined parts based on the blueprints in Assignment Sheet #2.
   - Show videotape presentation, "Evaluate First Run."

5. Use Section V of the information sheet to discuss calculating revised offsets; use Assignment Sheet #3 to reinforce objective.

6. Use Section VI of the information sheet to discuss when edits are necessary.

   SUGGESTIONS:

   - Invite a programmer to talk to the class about the evolution of a program.
   - Use Assignment Sheet #4 to reinforce objective.
   - Allow the students to discuss the editing required for their parts; provide the students with setup sheets to revise.

INSTRUCTIONAL OVERVIEW

7. Use Section VII of the information sheet to discuss when setup changes are necessary.

   SUGGESTIONS:

   - Have the students discuss possible setup changes that might overcome the defects in the parts they evaluated in Assignment Sheet #2.
   - Have the students discuss possible setup changes that may be required for their next run; provide the students with setup sheets to revise.

H. Demonstrate job sheets as necessary.

SUGGESTIONS:

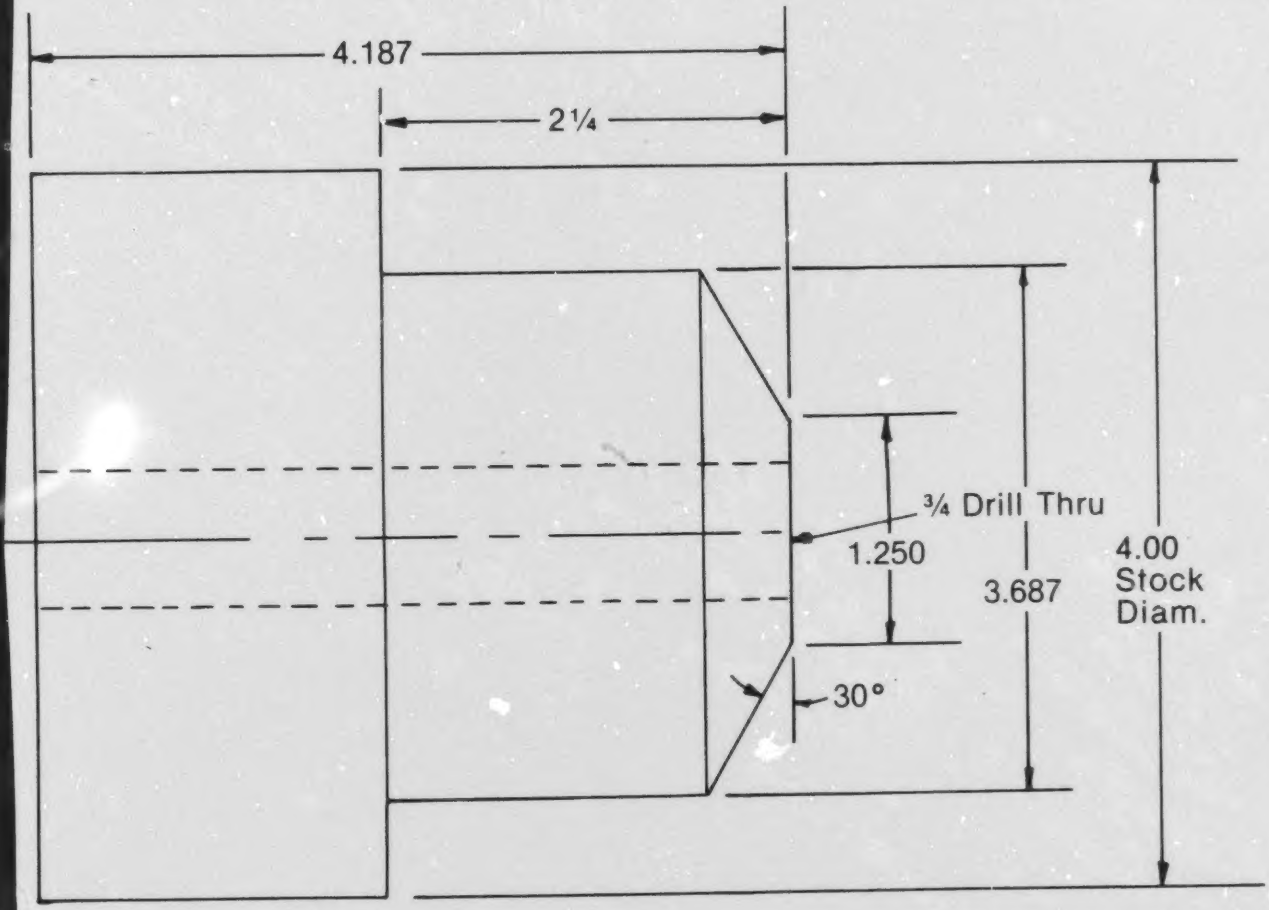
- Show videotape presentations of procedures.
- Encourage students to use the control unit photograph contained in Unit III to study the job sheets so that they can follow the outlined procedures.

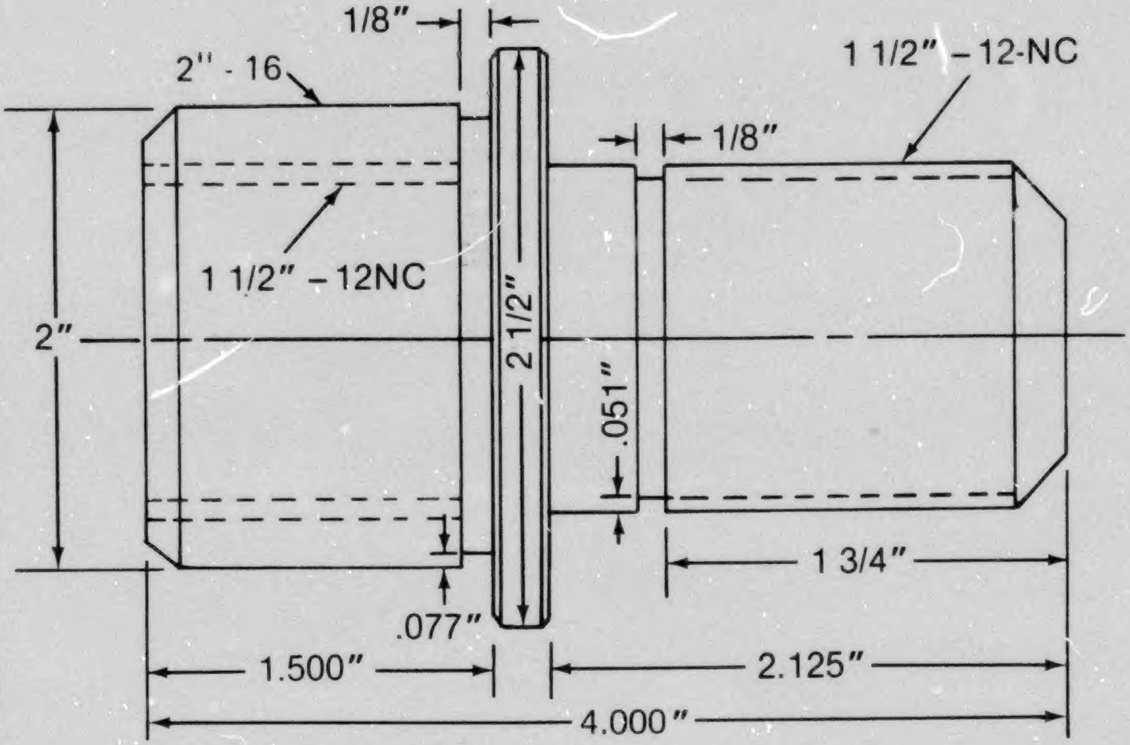
I. Allow students to edit programs and perform second run.

J. Give test.

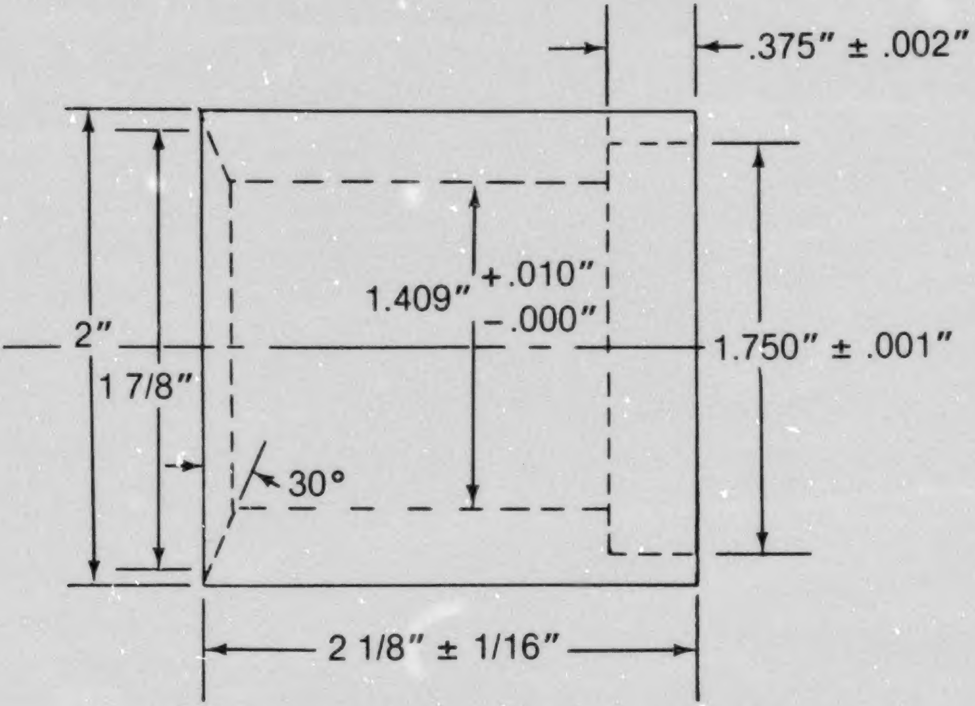
(NOTE: For the last test item, the students should label and turn in their first and second run parts along with Assignment Sheets #2, #3, and #4 and their evaluation of the second run for you to evaluate.)

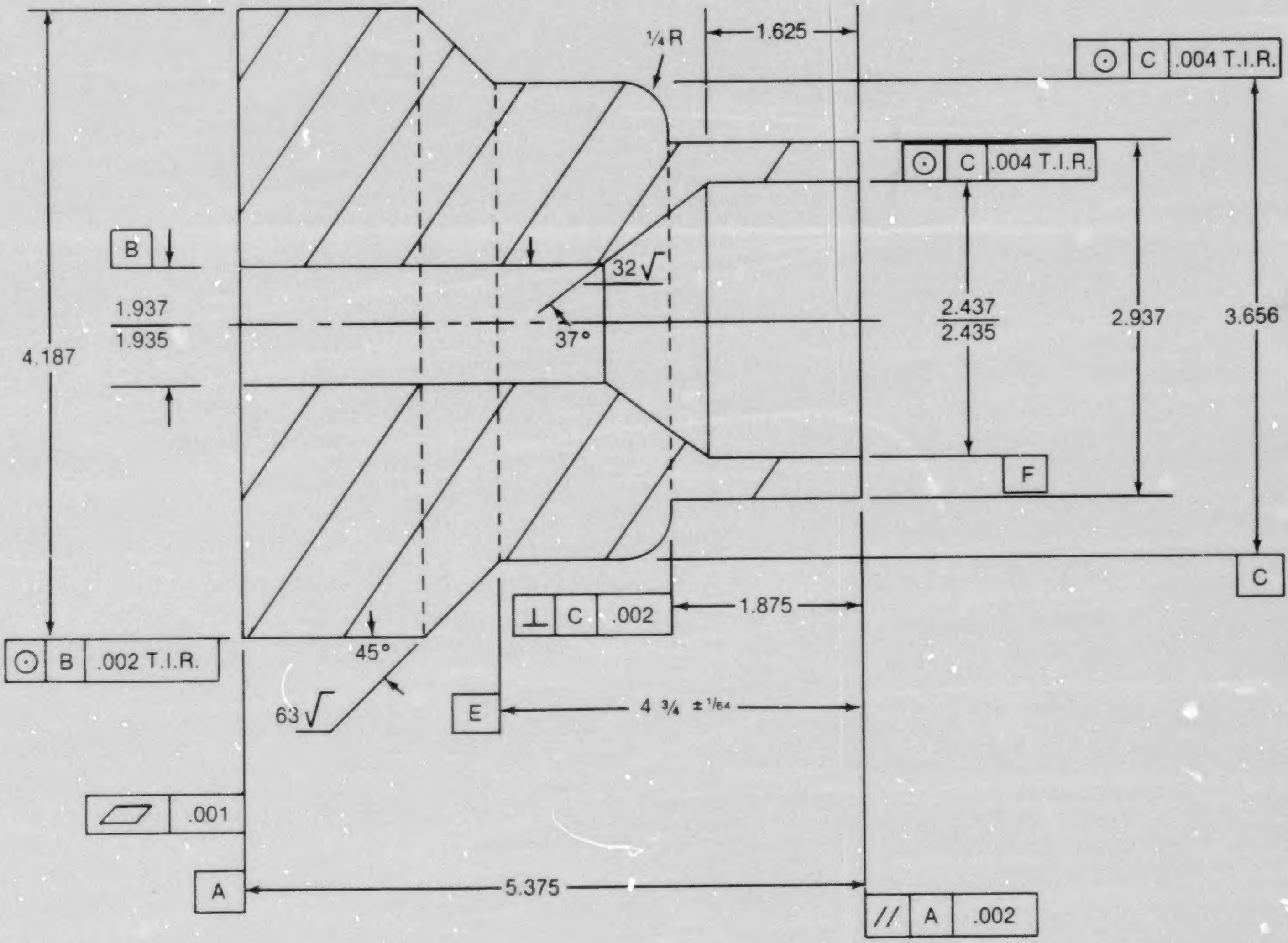
K. Reteach and retest if necessary.


4.187
2¼
¾ Drill Thru
1.250
3.687
4.00
Stock
Diam.
30°



1/8″
2″ - 16
1 1/2″ – 12-NC
1/8″
1 1/2″ – 12NC
2″
2 1/2″
.051″
1 3/4″
.077″
1.500″
2.125″
4.000″


.375″ ± .002″
2″
1 7/8″
1.409″ +.010″ −.000″
1.750″ ± .001″
30°
2 1/8″ ± 1/16″


¼R
1.625
⊙ C .004 T.I.R.
⊙ C .004 T.I.R.
B
32
1.937
1.935
37°
4.187
2.437
2.435
2.937
3.656
F
C
⊥ C .002
1.875
45°
⊙ B .002 T.I.R.
63
E
4 ¾ ± 1/64
▱ .001
A
5.375
// A .002

EVALUATE FIRST RUN
UNIT IV

INFORMATION SHEET

I. Terms and definitions

A. First article inspection (first run inspection) — Evaluation of a part produced using either manual or computer-controlled preset positions to determine how well part meets tolerances

B. Tolerance — Amount of error allowed in attaining a particular dimension

(NOTE: Tolerance may be *unilateral* or *bilateral*. A unilateral tolerance means that the dimension has an allowable error in only one direction. For example, a dimension with a +0.005" can be up to 0.005" greater than what the blueprint shows but it cannot be less than the blueprint dimension. A bilateral tolerance allows an error in either direction. A bilateral tolerance may be the same or different for the two directions.)

EXAMPLES: 1. Unilateral — +0.005";-0.1mm
2. Bilateral — ±0.005"; $\frac{+.001''}{-.005''}$

C. Limit — Dimension with the allowable tolerance

EXAMPLE: For a 3.500" dimension with a tolerance of ±0.005", the upper limit is 3.505" and the lower limit is 3.495".

D. Mean dimension — Dimension halfway between the limit dimensions

E. Clearance — Amount of allowable distance between two parts when they are assembled

F. Deviation — Total difference between a specified blueprint dimension and the actual measurement of the part

G. Total indicator reading (T.I.R.) — Difference in indicator readings between point of highest reading and point of lowest reading

H. Flatness — Condition specified on a part print to denote maximum deviation from perfectly flat

I. Perpendicularity — Condition specified on a part print to denote maximum deviation from two surfaces being perfectly square to each other

J. Parallelism — Condition specified on a part print to denote maximum deviation from two surfaces being perfectly parallel to each other

INFORMATION SHEET

K. Concentricity — Condition specified on a part print to denote the maximum deviation from two or more diameters sharing the same center line

L. True position — Condition specified on a part print to denote that a point location is based on the location of another point

EXAMPLE: A bolt-hole pattern on the face of a round part is not dimensioned with a centerline. The true positions of the holes are based on the center of the part.

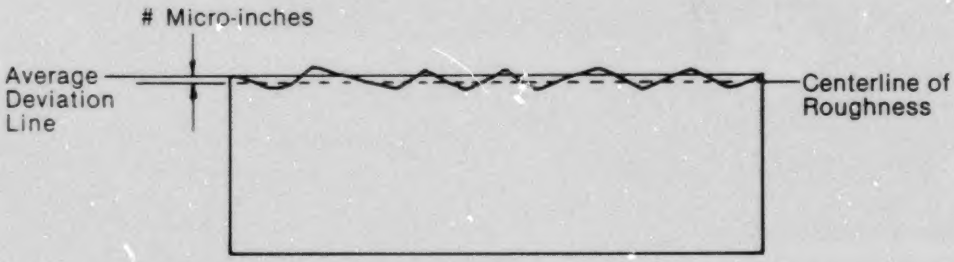
M. Out-of-round — Condition specified on a part print to denote maximum deviation from perfect roundness

N. Surface finish — Condition specified on a part print to denote degree of smoothness in the surface

(NOTE: Surface finishes are given numerical values; the higher the number, the rougher the surface finish. The numbers represent smoothness as the average deviation from a centerline through the minute peaks and valleys of the surface, as shown in Figure 1. The amount of deviation is measured in micro-inches, or 0.000001".)

EXAMPLE:

FIGURE 1



INFORMATION SHEET

II. Items to check on a visual inspection of first run

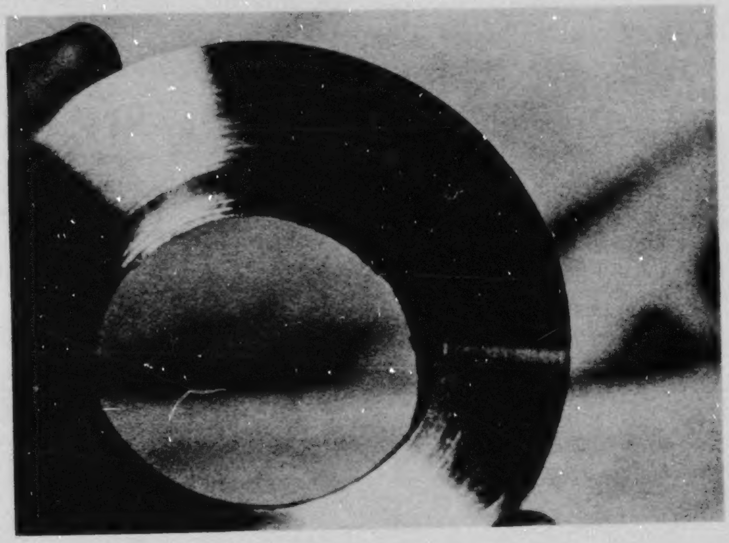
A. Part

1. Check for burrs (Figure 2)

(NOTE: Excessive burring may indicate that the incorrect tool is being used or that radius or chamfer programming is wrong.)

EXAMPLE:

FIGURE 2



INFORMATION SHEET

2. Check for chatter, or other tool marks (Figure 3)

   (NOTE: Tool marks indicate that the wrong tool, wrong feeds and speeds, or wrong holder is being used or that tools or parts were not securely mounted.)

   EXAMPLE:

FIGURE 3

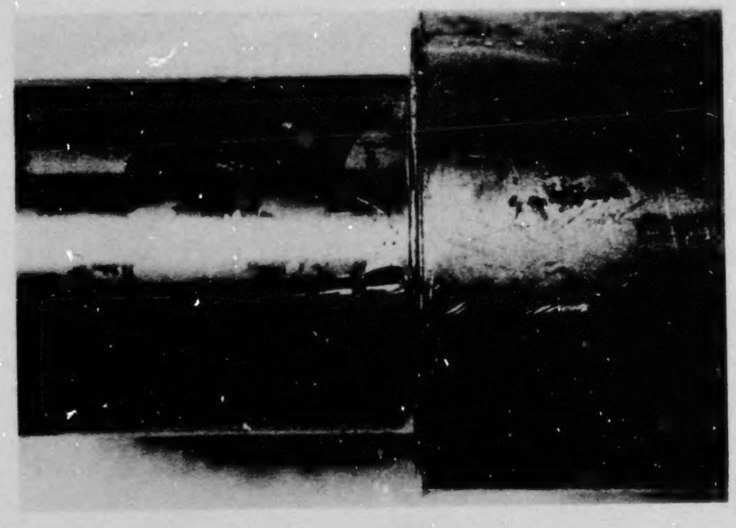
INFORMATION SHEET

3. Check for jaw marks (Figure 4)

(NOTE: If jaw marks show on the finished surface, this indicates that the wrong jaws are being used or that they are being used improperly.)

EXAMPLE:

FIGURE 4



INFORMATION SHEET

B. Tools

1. Check for excessive burning of cutting edges

   (NOTE: Excessive burning indicates the use of the wrong coolant or inadequate coolant or incorrect spindle speeds.)

2. Check for breaking or chipping of cutting edges

   (NOTE: Broken or chipped cutting edges indicate excessive feeds, improper clearance, incorrect tool, or improper alignment of part.)

C. Chips — Check to see that chips are short and curled

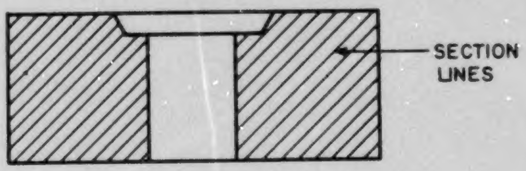
(NOTE: Long, stringy chips indicate the need for an increased feed rate or better chip breaking from the tool because of using the wrong tool, a damaged tool, or the wrong rake angle.)

III. Blueprint symbols

A. Section lines — Indicate that the view shown is as if a portion of the part had been cut away (Figure 5)

EXAMPLE:

FIGURE 5

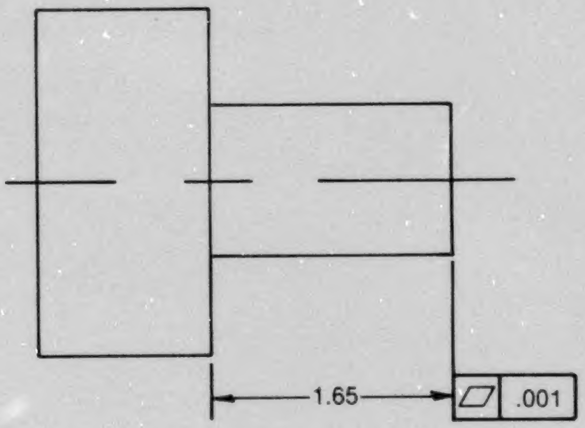


INFORMATION SHEET

B. ▱ — Indicates need for a surface to be within a certain tolerance for flatness (Figure 6)

EXAMPLE:

FIGURE 6

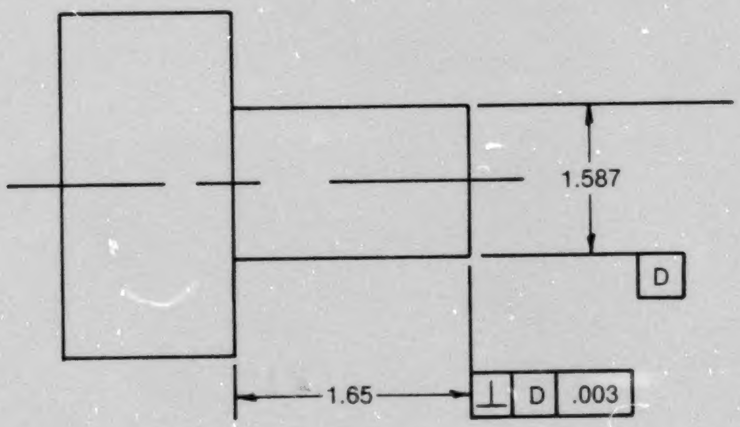


(NOTE: Face must be within 0.001" of being flat.)

C. ⊥ — Indicates that edge or surface must be within a certain tolerance of perpendicularity with another edge or surface (Figure 7)

EXAMPLE:

FIGURE 7



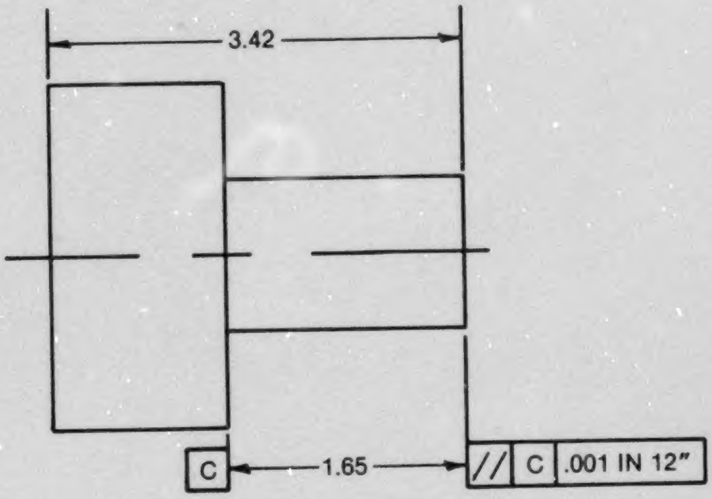
(NOTE: The 1.587" face must be perpendicular to the centerline of D within 0.003".)

INFORMATION SHEET

D. // — Indicates that edge or surface must be within a certain tolerance of parallelism with another edge or surface (Figure 8)

EXAMPLE:

FIGURE 8



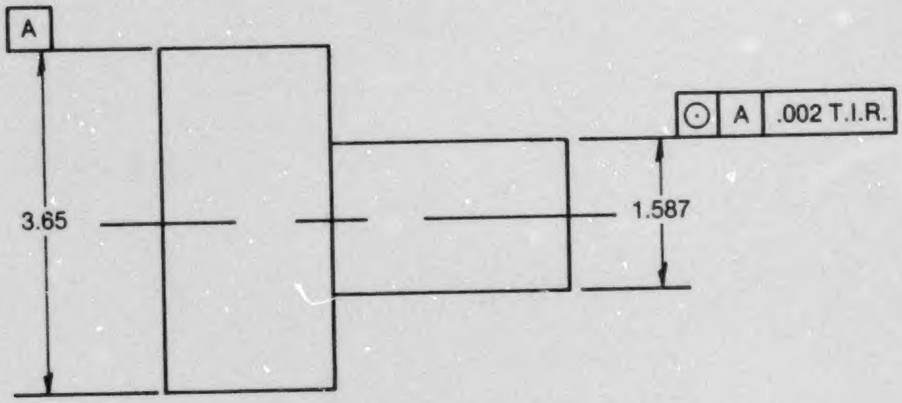
(NOTE: The two faces must be parallel to each other within 0.001" for each 12" of surface plane)

INFORMATION SHEET

E. ⊙ — Indicates that diameter must be within a certain tolerance of concentricity with another diameter (Figure 9)

EXAMPLE:

FIGURE 9



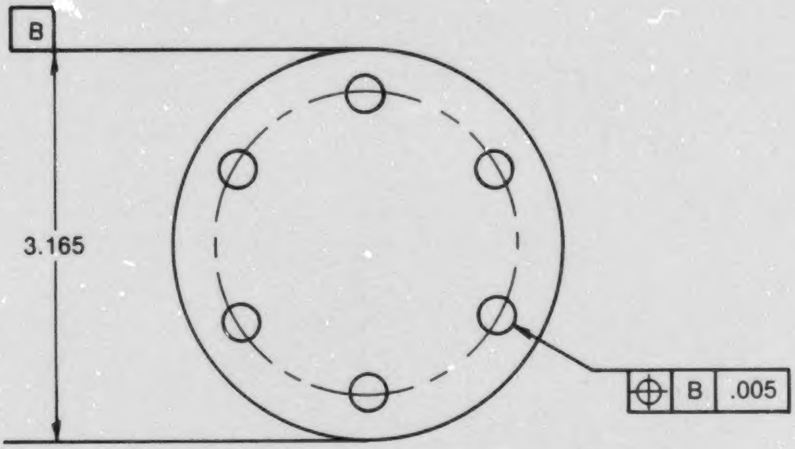
(NOTE: The two diameters must be concentric within 0.002" over the total indicator reading.)

INFORMATION SHEET

F. ⌖ — Indicates location by true position within a certain tolerance (Figure 10)

EXAMPLE:

FIGURE 10



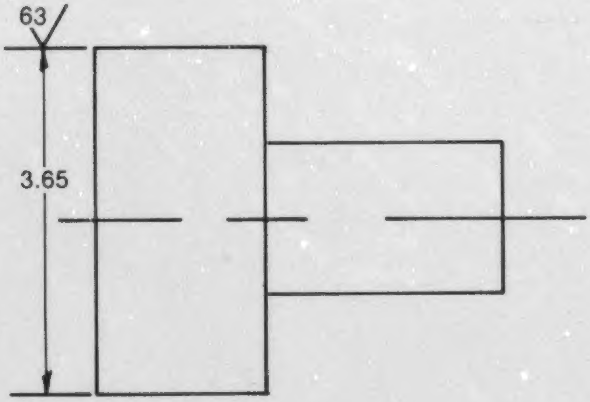
(NOTE: The circle of bolt holes must be within 0.005″ of true position with the part centerline.)

INFORMATION SHEET

G. ✓ — Indicates that surface finish must not exceed a certain tolerance (Figure 11)

EXAMPLE:

FIGURE 11



(NOTE: The surface finish on the part must not exceed 63 micro-inches average deviation from the centerline of surface roughness.)

INFORMATION SHEET

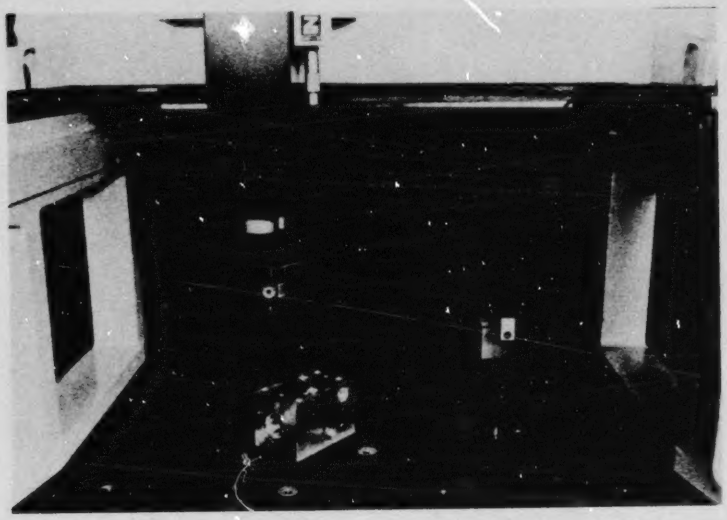
IV. Inspection tools

A. Coordinate measuring machine — Machine used to measure part dimensions (Figure 12)

(NOTE: Coordinate measuring machines are usually operated with a computer and are generally accurate to 0.000001".)

EXAMPLE:

FIGURE 12



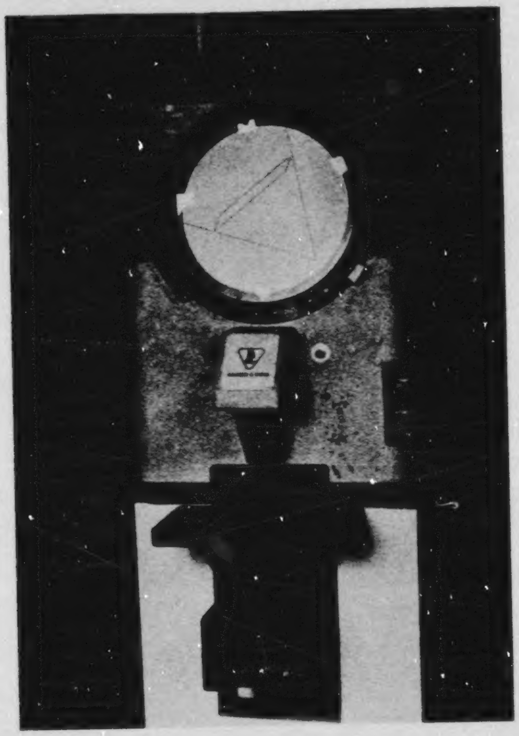
INFORMATION SHEET

B. Optical comparator — Machine that projects a magnified silhouette of a part onto a screen for close inspection (Figure 13)

(NOTE: Angles and radii can be measured on the silhouette.)

EXAMPLE:

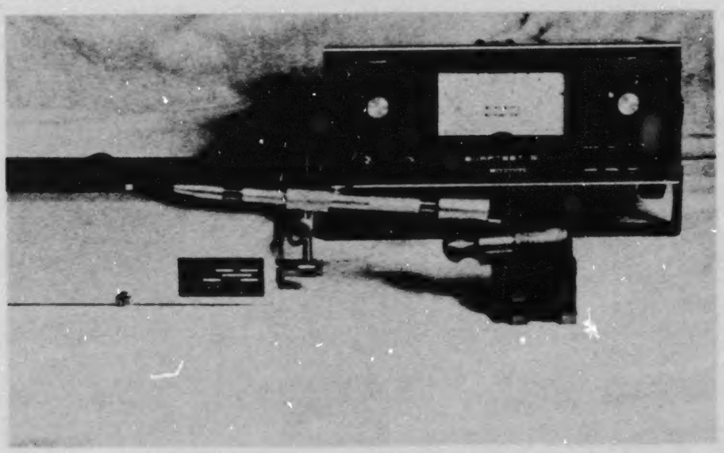
FIGURE 13



INFORMATION SHEET

C. Profilometer — Machine used to check surface finishes of parts (Figure 14)

FIGURE 14

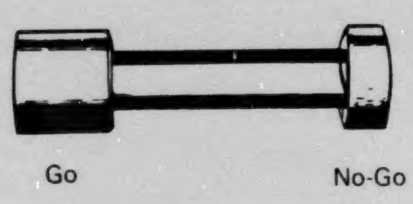


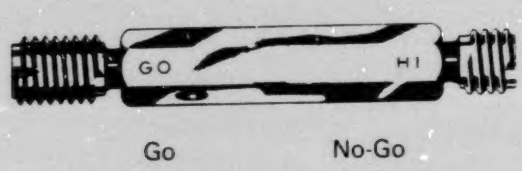
INFORMATION SHEET

E. Plug gauge — Tool used to check size of inside diameters on parts or for setting outside diameters on other measuring instruments (Figure 16)

EXAMPLE:

FIGURE 16





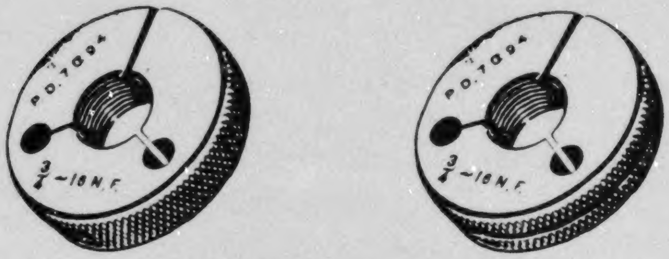
INFORMATION SHEET

D. Ring gauge — Tool used to check size of outside diameters on parts or for setting inside diameters on other measuring instruments (Figure 15)

EXAMPLE:

FIGURE 15

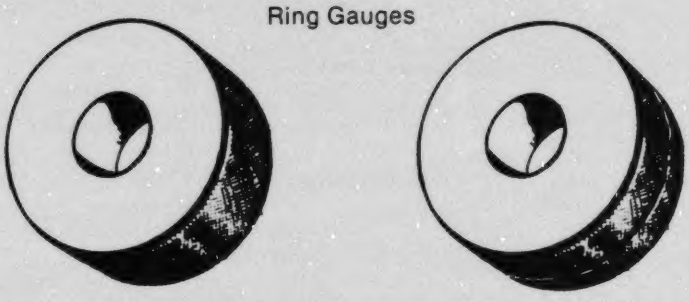
Thread Ring Gauges


P.D.7094
3/4-16 N.F.
P.D.7094
3/4-16 N.F.

Go

No-Go

Ring Gauges



Go

No-Go

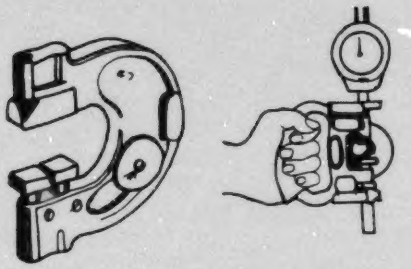
INFORMATION SHEET

F. Snap gauge — Tool used to check size of outside diameter (Figure 17)

(NOTE: Snap gauges are not suitable to check parts with a tolerance of less that 0.005" unless equipped with indicator gauge as shown on the right of Figure 17.)

EXAMPLE:

FIGURE 17

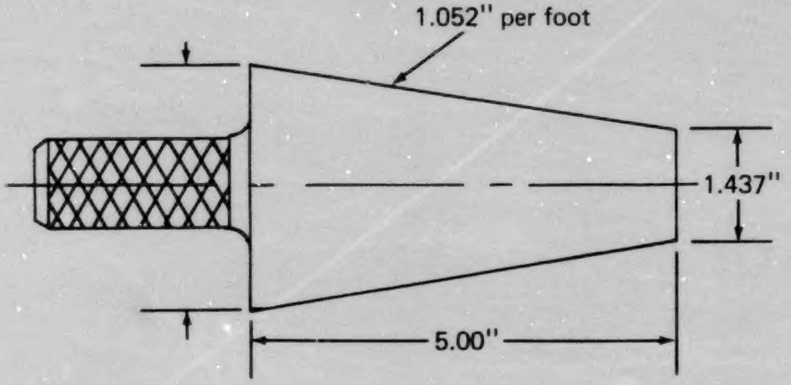


INFORMATION SHEET

G. Taper gauge — Tool used to check angles and diameters of tapers (Figure 18)

EXAMPLE:

FIGURE 18

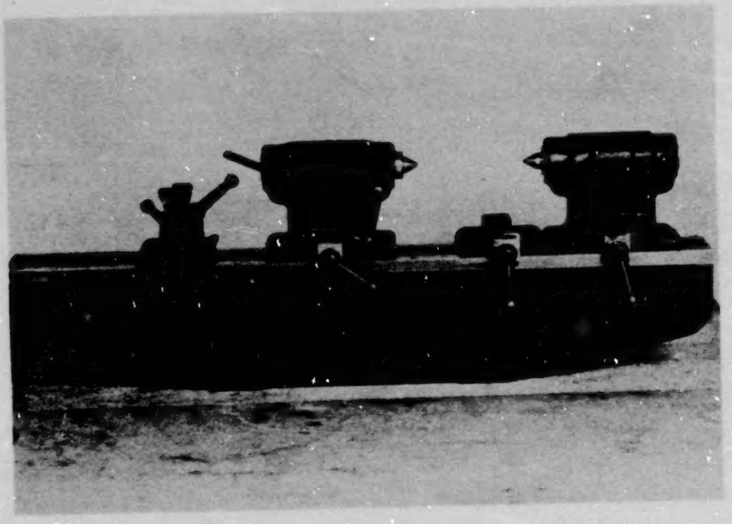

1.052" per foot
1.437"
5.00"

INFORMATION SHEET

H. Bench centers — Centers mounted on a precision ground bed used for holding parts between centers during bench inspection (Figure 19)

EXAMPLE:

FIGURE 19

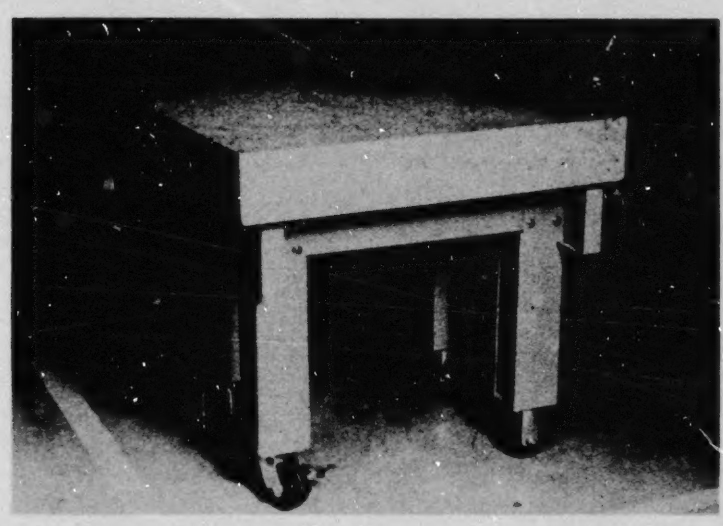


INFORMATION SHEET

I. Surface plate — Precisely ground granite plate used as an inspection surface (Figure 20)

EXAMPLE:

FIGURE 20



V. Items to check on a dimensional inspection

(NOTE: Items checked will depend on design and tolerances.)

A. Check surface finish

(NOTE: This will require the use of a profilometer.)

B. Check for out-of-round condition

C. Check outside diameters

D. Check inside diameters

E. Check lengths, including depths of bores

F. Check angles and tapers

G. Check flatness

H. Check perpendicularity

INFORMATION SHEET

I. Check parallelism

J. Check concentricity

K. Check locations

L. Check threads

VI. When program editing is necessary

(NOTE: In production machining with CNC equipment, the primary reason for making thorough visual and dimensional inspections is to make sure that the program produces the part the way that it needs to be made. A CNC machine will only do what it is commanded to do by the program and the operator. During first-run inspections, carefully note any flaws that are detected and change the program as necessary to bring the part within tolerances.)

A. Errors in tolerances

EXAMPLES: 1. Incorrect value in program — A print calls for diameters to be 1.687" and 2.375", but the actual diameters are 1.687" and 2.377"; the printout for that portion of the program is:

```
N290 G01 × 1.687
N300 Z-1.53
N310 × 2.377
N320 Z- 2.386
N330 ×- 2.5
N340 G00 × 7.75 Z 13.085 T0100
```

(NOTE: The dimension at N0310 is incorrect. The program should show 2.375".)

2. Incorrect offsets

B. Incorrect surface finishes

(NOTE: Incorrect surface finishes may result from the wrong feed rate. Feed should be decreased to improve surface finish.)

C. Chatter or other tooling marks

INFORMATION SHEET

VII. Actions to take for setup flaws

(NOTE: Production errors often result from improper setups. Check the tooling before making program changes.)

A. Chatter or other tooling marks

1. Check to see that tool is securely fastened

   (NOTE: Chatter from more than one tool may indicate that the part was not securely held.)

2. Check to see that tool is not extended too far

B. Jaw marks

1. If using hard jaws, change to soft jaws
2. If using soft jaws, rebore soft jaws

C. Errors in tolerances when program is correct

1. Check for proper tools
2. Check equipment for loose or worn parts
3. Check alignment of spindle
4. Check trueness of chuck

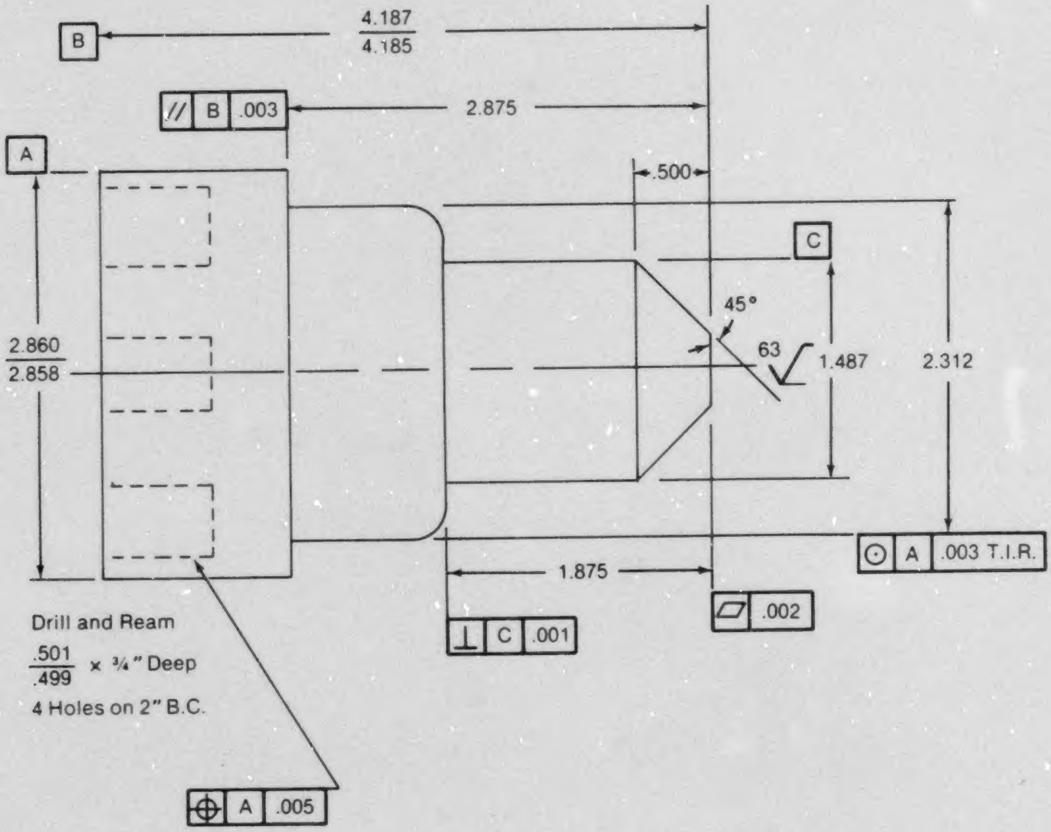
EVALUATE FIRST RUN
UNIT IV

ASSIGNMENT SHEET #1 — READ BLUEPRINT

NAME ______________________________ SCORE ______________

Every step in machining from setup and programming to production and inspection relies on the ability to understand blueprints. The entire point of machining is to convert the lines and instructions on a blueprint to an actual machined part. The evaluation of that part is done in terms of how well it matches the blueprint specifications.

Study the blueprint drawing below and answer the questions on the next page.


B
4.187
4.185
// | B | .003
2.875
A
.500
C
45°
63
1.487
2.312
2.860
2.858
1.875
⊥ | C | .001
▱ | .002
◎ | A | .003 T.I.R.
Drill and Ream
.501
.499
× ¾" Deep
4 Holes on 2" B.C.
⊕ | A | .005

ASSIGNMENT SHEET #1

A. What tolerances are given for the following characteristics of the part?

1. Parallelism — ______________________
2. True position — ______________________
3. Perpendicularity — ______________________
4. Flatness — ______________________
5. Concentricity — ______________________

B. What surface finish is specified for the tapered portion of the part? __________

C. What is the mean dimension for the largest diameter? __________

D. What is the maximum overall length of the part? __________

E. What does the abbreviation *T.I.R.* stand for? ______________________

EVALUATE FIRST RUN
UNIT IV

ASSIGNMENT SHEET #2 — INSPECT PART

NAME ______________________________ SCORE ______________

Once the first run has been made, the next step is to inspect the part visually and dimensionally to see that it meets standards. Such inspections are very important, especially early in the production process when a simple program change may prevent the operator from producing several hundred or even thousands of wrong-size parts.

Your instructor will provide you with a part and the blueprint for that part. Inspect the part and report your findings below.

(NOTE: Your instructor may want you to use Job Sheet #1 to run a part and use this assignment sheet along with Job Sheet #2 to evaluate the part you have made.)

A. Visual inspection

1. Part

a. Are burrs present? ________ If so, where?

____

____

____

(NOTE: You may want to mark flaws on a copy of the print.)

b. What kinds of tooling marks, if any, are present and where?

____

____

____

____

c. Are jaw marks present and where? ______________________________

____

____

____

ASSIGNMENT SHEET #2

2. Tools

(NOTE: If the machine tooling is available check it also.)

a. Do any tools have burnt cutting edges?________________________

Which ones, if any?______________________________

____

____

b. Are any of the cutting edges chipped or broken? ________ If so, which ones?

____

____

____

3. Chips

(NOTE: If chips from the machining operation are available, check them also.)

a. Are the chips short or long?____________________________

b. Are the chips curled or stringy?__________________________

B. Review Section V of the information sheet to see how many of the dimensional inspection items apply to the part you are evaluating. List below any dimensions or surfaces that are out of tolerance.

EVALUATE FIRST RUN
UNIT IV

ASSIGNMENT SHEET #3 — CALCULATE REVISED OFFSET VALUES

NAME ______________________________ SCORE ______________

The creation of an accurate program requires a number of steps and revisions. One of the revisions that may be necessary after a first run is evaluated is the calculation of new offset values. Read the following situations and calculate new offset values.

A. A part measures 1.635" across one diameter while the blueprint specifies 1.639 ± .001". What offset is required?

Offset ______________________

B. A part is 4.193" long. What offset is required if the print calls for a 4 3/16" length and specifies a tolerance of ± 1/64" for fractional dimensions?

Offset ______________________

ASSIGNMENT SHEET #3

C. A bore diameter measures 0.642". The blueprint calls for 0.640±.001". What offset is required?

Offset ______________________

D. A groove on a part is 1.383" from a face that is shown to be 1 3/8" ± 1/64" on the print. What offset is required?

Offset ______________________

E. A part's overall length is 5.165 while the print calls for 5.25" ± 0.002". What offset is required?

Offset ______________________

ASSIGNMENT SHEET #3

F. What offset revisions are required on the part you ran in light of your evaluation?

____

____

____

____

____

EVALUATE FIRST RUN
UNIT IV

ASSIGNMENT SHEET #4 — DETERMINE REQUIRED PROGRAM AND SETUP CHANGES

NAME ________________________________ SCORE ______________

The goal of evaluating the first run is to correct any errors in the program or setup before the production run is started. The part, program, and tooling must be examined closely in every detail to bring the product in to as near a match as possible.

In the problems below, you will be asked to make decisions concerning changes in programs and setups. Read the information in each part and make the required changes.

A. Determine program edits required.

1. The first bore on a part is 1.637" and the second bore is 1.383". The print calls for 1.625" and 1.383". Edit the program below as required.

```
N0340 G01 X1.637 Z-.125
N0350 Z-1.375
N0360 X1.383
N0370 Z-2.0
N0380 X1.35
N0390 G00 Z.1
```

2. One shoulder is 0.876" from a face and a second shoulder is 1.346" from the face. The print calls for 7/8" and 1 5/16" respectively. Indicate any required edits in the program below.

```
N0760 G01 Z-.875
N0770 G02 X2.65 Z-1.0 I0 K.125
N0780 G01 Z-1.343
N0790 X2.7
N0800 G00 X7.75 Z13.085 T0200
```

3. One shoulder is 4.006" and another shoulder is 1.193" from the face. The print calls for shoulder locations of 4" and at 1 3/16". What edits are required in the program below?

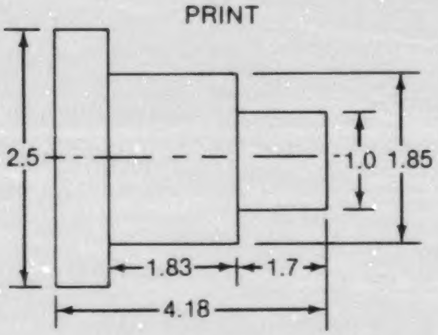
```
N0450 G00 X3.5 Z0
N0460 G01 X0 F.006
N0470 G00 Z.1
N0480 X3.375
N0490 G01 Z-1.187
N0500 X3.45
N0510 Z-4.00
```

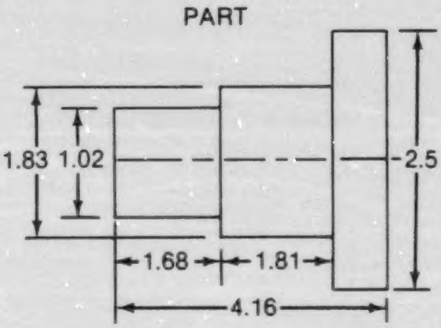
ASSIGNMENT SHEET #4

4. The first O.D. on a part is 3.997" and the second is 4.094". If the print calls for 3.937" and 4 $^{3}/_{32}$". What program edits are required?

```
N1040 G01 Z-1.375
N1050 X3.997
N1060 Z-2.0
N1070 X4.0938
N1080 Z-2.5
N1090 X4.2
```

5. The drawing on the left below shows the print for a part. The drawing on the right shows the dimensions of the test run part. Indicate program edits and setup changes as required on the sequence for the O.D. finish tool.





```
N0010 G20 G99 G00 T0100
N0020 G50 X8.5 Z10.0 S2000
N0030 G96 S650 M03
N0040 G00 X1.02 Z0 M08 T0101
N0050 G01 X0 F.0150
N0060 G00 Z.01
N0070 X1.02
N0080 G01 Z-1.7
N0090 X1.83
N0100 Z-3.53
N0110 X2.5
N0120 Z-4.18
N0130 G00 X2.51
N0140 X8.5 Z10.0 T0100 M09
N0150 M01
```

ASSIGNMENT SHEET #4

B. Once you have done your first run, indicate the changes required on a printout of the program.

EVALUATE FIRST RUN
UNIT IV

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

A. 1. 0.003"

   2. 0.005"

   3. 0.001"

   4. 0.002"

   5. 0.003" T.I.R.

B. 0.000063"

C. 2.859"

D. 4.187"

E. Total indicator reading

Assignment Sheet #2 — Evaluated to the satisfaction of the instructor.

Assignment Sheet #3

A. X 0.004"

B. None required (part is in tolerance)

C. X −0.002

D. None required (part is in tolerance)

E. Z −0.085

F. Evaluated to the satisfaction of the instructor

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #4

A. 1. N0340 G01 X1.625 Z−.125

N0350 Z−1.375

N0360 X1.383

N0370 Z−2.0

N0380 X1.35

N0390 G00 Z.1

2. N0760 G01 Z−.875

N0770 G02 X2.65 Z−1.0 I0 K.125

N0780 G01 Z−1.312

N0790 X2.7

N0800 G00 X7.75 Z13.085 T0200

3. N0450 G00 X3.5Z0

N0460 G01 X0 F.006

N0470 G00 Z.1

N0480 X3.375

N0490 G01 Z−1.187

N0500 X3.45

N0510 Z−4.00

(NOTE: No program change is required. Because both Z dimensions are off by 0.006", an offset change is indicated.)

4. N1040 G01 Z−1.375

N1050 X3.937

N1060 Z−2.0

N1070 X4.0938

N1080 Z−2.5

N1090 X4.2

ANSWERS TO ASSIGNMENT SHEETS

5. N0010 G20 G99 G00 T0100

N0020 G50 X8.5 Z10.0 S2000

N0030 G96 S650 M03

N0040 G00 X1.02 Z0 M08 T0101

N0050 G01 X0 F.0150

N0060 G00 Z.01

1.0
N0070 X~~1.02~~

N0080 G01 Z-1.7

Z offset must be adjusted -0.02.

1.85
N0090 X~~1.83~~

N000 Z-3.53

N0110 X2.5

N0120 Z-4.18

N0130 G00 X2.51

N0140 X8.5 Z100 T0100 M09

N0150 M01

B. Evaluated to the satisfaction of the instructor.

EVALUATE FIRST RUN
UNIT IV

JOB SHEET #1 — RUN FIRST PART

I. Equipment and materials

- A. CNC lathe
- B. Operator's manual
- C. Work order and setup sheet
- D. Program tape and equipment necessary for loading
- E. Notes on program edits for first run
- F. Tools and materials required for part
- G. Shop towels
- H. Standard sets of tools and inspection equipment for lathe operations

II. Procedure

- A. Perform preventive maintenance
- B. Prepare work station for production
- C. Power up and check machine
- D. Set up jaws
- E. Load program if required
- F. Move *U* and *W* slides to program home position
- G. Determine initial offsets and store in control
- H. Chuck on workpiece
- I. Close guard door
- J. Set mode select switch to *EDIT*
- K. Press *PRGRM* key
- L. Press *RESET* key
- M. Check program information to see that correct program is loaded

JOB SHEET #1

N. Press yellow *SINGLE BLOCK* button to illuminate light

O. Press *POS* key

P. Press either *PAGE* key to display *DISTANCE TO GO*

Q. Press *CYCLE START* button

(NOTE: Once the *CYCLE START* button has been pressed, the first block of the program will be loaded. The operator must press the button again for each program block to be loaded.)

R. Continue to press *CYCLE START* button until tool moves to part

S. Monitor operation of machine to completion of first part

(NOTE: Watch for signs of incorrect settings, such as the tool not contacting the workpiece or *DISTANCE TO GO* readings that are too small to allow completion of operation. Observe for sequences that are counterproductive to each other. Watch for excessive sparking and poor chipping, and listen for noisy machining which may indicate incorrect speed, feeds, or cutting angles.)

1. Stop machine and inspect tool and part after each tool operation
2. Change offsets as required
    - a. Press *MENU OFFSET* key
    - b. Move cursor to tool number where change is to be made
    - c. Press *U* key for a change in X offset and *W* for a change in Z offset, followed by the calculated change in offset value
    - d. Press *INPUT* key
3. Rerun tool if offset was changed
    - a. Return to setup position
    - b. Set mode select switch to *EDIT*
    - c. Press *RESET* key
    - d. Key in block number of tool to be run
    - e. Press the *CURSOR* down button to move cursor to block number

JOB SHEET #1

f. Place mode select switch in *AUTO*

g. Press *CYCLE START* button

4. Repeat steps 1-3 until offset is correct

T. When operation is complete, place mode select switch in *MDI* position and turn the machine enable key switch to *OFF*

U. Open safety door and remove workpiece

V. Continue to the next procedure

EVALUATE FIRST RUN
UNIT IV

JOB SHEET #2 — EVALUATE FIRST RUN

I. Equipment and materials

- A. CNC lathe used to run first part
- B. Machined part
- C. Work order and setup sheet
- D. Inspection equipment

II. Procedure

(NOTE: The sequence of the inspection may depend on the tools used, specified tolerances and design of part, inspection equipment used, and inspector preferences. This procedure outlines steps to follow, but the order may vary.)

- A. Check part for burrs
- B. Check part for tool marks
- C. Check part for jaw marks
- D. Check tools for excessive burning of cutting edges
- E. Check tools for broken or chipped cutting edges
- F. Check to see that chips are short and curled
- G. Measure inside and outside diameters; compare to tolerances
- H. Measure all lengths; compare to tolerances
- I. Check angles and tapers; compare to tolerances
- J. Check radii; compare to tolerances
- K. Check threads; compare to specifications
- L. Check part for out-of-round condition
  - 1. Clean part and precision V-block
  - 2. Place part in V-block

JOB SHEET #2

3. Position dial indicator to indicate perpendicular to diameter to be checked with a preload of 0.005" to 0.010"
4. Zero indicator
5. Carefully turn part in V-block one complete revolution and observe dial indicator

   (NOTE: The indicator will remain on zero if the part is round. The total amount of indicator needle movement represents the T.I.R.)

6. Compare reading to tolerance

M. Check for concentricity where required

1. Repeat step L for each concentric diameter
2. Compare T.I.R.s for each diameter

   (NOTE: If three or more diameters must be concentric, use one diameter as a reference to compare the others to.)

3. Compare results to tolerances

   (NOTE: Concentricity tolerances are normally given as a distance deviation from the center line. The T.I.R. of a diameter will be twice its actual deviation from the centerline.)

N. Check for parallelism where required

1. Wipe surface plate, bottom of height gauge, and parallel surfaces of part
2. Place part on plate with one parallel surface down
3. Attach dial indicator to height gauge
4. Position indicator to indicate on top of parallel side near edge and zero indicator with a preload of 0.005" to 0.010"
5. Slide indicator to opposite side and note reading

   (NOTE: This procedure will indicate deviation from flatness between the two surfaces.)

JOB SHEET #2

6. Take readings at two other points

   (NOTE: The greatest reading represents the amount of deviation from the two surfaces being parallel. If more than two surfaces must be parallel, use the surface against the plate as a reference for the other surfaces if possible.)

O. Check for perpendicularity where required

   1. Clean part and V-block
   2. Place part in V-block
   3. Set stop at end of part to prevent it from shifting as the part is turned
   4. Position indicator to read on shoulder or face to be checked with a preload of 0.005" to 0.010"; zero indicator
   5. Turn part and observe indicator reading

      (NOTE: This procedure will show the amount of deviation from being square between the shoulder or face and the diameter.)

P. Check surface finish of part

   1. Turn on profilometer
   2. Adjust the height of the stylus so that the arm is as close as possible to the area to be measured
   3. Set stylus of profilometer so that it will traverse across surface to be checked without going off the part
   4. Turn off profilometer
   5. Select range of reading

      (NOTE: Most profilometers have a dial to set the range. For example, a machine may have scales of 0-30, 30-100, and 100-300 microinches.)

   6. Turn on profilometer and allow arm to traverse area
   7. Observe profilometer
   8. Turn off profilometer
   9. Compare highest reading to tolerances

Q. Continue to the next procedure

EVALUATE FIRST RUN
UNIT IV

JOB SHEET #3 — EDIT PROGRAM AND CHANGE SETUP AS REQUIRED

I. Equipment and materials

- A. CNC lathe used to run first part
- B. Operator's manual
- C. Notes on first run evaluation
- D. Work order and setup sheet
- E. Shop towels
- F. Standard sets of tools and inspection equipment for lathe operations

II. Procedure

- A. Review inspection notes for out-of-tolerance conditions
- B. Evaluate out-of-tolerance conditions to determine whether they result from program or setup errors
- C. Check machine for loose or worn parts; check spindle alignment
- D. Review setup sheet
- E. Check setup
  - 1. Check to see that correct tools and inserts are installed
  - 2. Check to see that tools and inserts are correctly installed
  - 3. Check to see that tools and holders are secure
- F. Correct setup flaws if required

  EXAMPLES: Replace incorrect or damaged tools, align drills, tighten loose tools
- G. Review program and print
- H. Change program if incorrect
- I. Calculate and load new offsets if required
- J. Continue to the next procedure

EVALUATE FIRST RUN
UNIT IV

JOB SHEET #4 — RUN AND EVALUATE SECOND PART

I. Equipment and materials

A. CNC lathe with setup changed and program edited as required after first run

B. Operator's manual

C. Work order and setup sheet

D. Tools and materials required to machine part

E. Shop towels

F. Standard sets of tools and inspection equipment for lathe operations

II. Procedure

A. Prepare work station for production

B. Power up and check machine if required; turn enable key switch to *ON*

C. Move *U* and *W* slides to program home position

D. Chuck on workpiece

E. Set mode select switch to *AUTO*

F. Close guard door

G. Press yellow *SINGLE BLOCK* button to illuminate light

H. Press *CYCLE START* button at start of each block

I. Press *POS* key

J. Press either *PAGE* key to display page with four separate displays

K. Monitor operation of machine to completion of second part

L. When operation is complete, place mode selector switch to *MDI* and turn the machine enable key switch to *OFF*

M. Open safety door and remove workpiece

N. Visually and dimensionally inspect part

JOB SHEET #4

O. Edit program and change setup as required

P. Run additional parts and evaluations as necessary

(NOTE: At the beginning of a production run, the technician will often perform a 100 percent inspection of the first ten or more parts.)

Q. Shut down machine and clean area

EVALUATE FIRST RUN
UNIT IV

TEST

NAME ________________________________ SCORE ______________

1. Match terms associated with machining evaluation to their correct definitions. Write the correct numbers in the blanks.

______a. Dimension halfway between the limit dimensions

______b. Condition specified on a part print to denote maximum deviation from perfectly flat

______c. Condition specified on a part print to denote the maximum deviation from two or more diameters sharing the same center line

______d. Evaluation of a part produced using either manual or computer-controlled preset positions to determine how well part meets tolerances

______e. Condition specified on a part print to denote maximum deviation from perfect roundness

______f. Condition specified on a part print to denote maximum deviation from two surfaces being perfectly parallel to each other

______g. Amount of allowable distance between two parts when they are assembled

______h. Condition specified on a part print to denote maximum deviation from two surfaces being perfectly square to each other

______i. Amount of error allowed in attaining a particular dimension

______j. Total difference between a specified blueprint dimension and the actual measurement of the part

______k. Condition specified on a part print to denote that a point location is based on the location of another point

1. First article inspection
2. Tolerance
3. Limit
4. Mean dimension
5. Clearance
6. Deviation
7. Total indicator reading
8. Flatness
9. Perpendicularity
10. Parallelism
11. Concentricity
12. True position
13. Out-of-round
14. Surface finish

TEST

______l. Condition specified on a part print to denote degree of smoothness in the surface

______m. Difference in indicator readings between point of highest reading and point of lowest reading

______n. Dimension with the allowable tolerance

2. Select from a list items to check during a visual inspection of first run. Place an "X" in the blank beside each correct answer.

______a. Check part for chatter, checking, or other tool marks

______b. Check to see that chips are short and curled

______c. Check oil levels

______d. Check tools for excessive burning of cutting edges

______e. Check part for jaw marks

______f. Check program number

______g. Check tools for breaking or chipping of cutting edges

______h. Check part for burrs

TEST

3. Match blueprint symbols to their correct meanings. Write the correct numbers in the blanks.

_____a. Indicate that the view shown is as if a portion of the part had been cut away

_____b. Indicates a need for a surface to be within a certain tolerance for flatness

_____c. Indicates that edge or surface must be within a certain tolerance of perpendicularity with another edge or surface

_____d. Indicates that edge or surface must be within a certain tolerance of parallelism with another edge or surface

_____e. Indicates that diameter must be within a certain tolerance of concentricity with another diameter

_____f. Indicates location by true position within a certain tolerance

_____g. Indicates that surface finish must not exceed a certain tolerance

1. ⊥
2. ⊙
3. //
4. Section lines
5. ✓
6. ▱
7. ⌖

TEST

4. Match inspection equipment to their correct descriptions. Write the correct numbers in the blanks.

_____a. Tool used to check size of outside diameters

_____b. Precisely ground granite plate used as an inspection surface

_____c. Machine that projects a magnified silhouette of a part onto a screen for close inspection

_____d. Tool used to check size of inside diameters on parts or for setting outside diameters on other measuring instruments

_____e. Centers mounted on a precision ground bed used for holding parts between center during bench inspection

_____f. Machine used to check surface finishes of parts

_____g. Tools used to check angles and diameters of tapers

_____h. Tool used to check size of outside diameters

_____i. Machine used to measure part dimensions

1. Coordinate measuring machine
2. Optical comparator
3. Profilometer
4. Ring gauge
5. Plug gauge
6. Snap gauge
7. Taper gauge
8. Bench centers
9. Surface plate

5. Select from the following list items to check during a dimensional inspection of first run. Write an "X" in the blank before each correct answer.

_____a. Check locations

_____b. Check surface finish

_____c. Check concentricity

_____d. Check to see that guard door was closed

_____e. Check for out-of-round condition

_____f. Check outside diameters

TEST

______g. Check parallelism

______h. Check inside diameters

______i. Check perpendicularity

______j. Check dimensions of keyways

______k. Check hydraulic oil filter for clogging or tears

______l. Check lengths, including depths of bores

______m. Check flatness

______n. Check angles and tapers

______o. Check threads

6. Name three indications that program editing may be necessary.

a. ________________________________

b. ________________________________

c. ________________________________

7. List actions to take for setup flaws.

a. Chatter or other tooling marks

1) ________________________________

2) ________________________________

b. Jaw marks

1) ________________________________

2) ________________________________

c. Errors in tolerances when program is correct

1) ________________________________

2) ________________________________

3) ________________________________

4) ________________________________

TEST

(NOTE: Test questions 8 through 11 list the assignment sheets and job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

8. Read blueprint.

9. Calculate revised offset values.

10. Determine required program and setup changes.

11. Demonstrate the ability to

    a. Run first part.

    b. Evaluate first run.

    c. Edit program and change setup as required.

    d. Run and evaluate second part.

EVALUATE FIRST RUN
UNIT IV

ANSWERS TO TEST

1. a. 4
   b. 8
   c. 11
   d. 1
   e. 13
   f. 10
   g. 5
   h. 9
   i. 2
   j. 6
   k. 12
   l. 14
   m. 7
   n. 3

2. a, b, d, e, g, h

3. a. 4
   b. 6
   c. 1
   d. 3
   e. 2
   f. 7
   g. 5

4. a. 4
   b. 9
   c. 2
   d. 5
   e. 8
   f. 3
   g. 7
   h. 6
   i. 1

5. a, b, c, e, f, g, h, i, l, m, n, o

6. a. Errors in tolerances
   b. Incorrect surface finishes
   c. Chatter or other tooling marks

7. a. Chatter or other tooling marks
   1) Check to see that tool is securely fastened
   2) Check to see that tool is not extended too far

ANSWERS TO TEST

b. Jaw marks

    1) If using hard jaws, change to soft jaws

    2) If using soft jaws, rebore soft jaws

c. Errors in tolerances when program is correct

    1) Check for proper tools

    2) Check equipment for loose or worn parts

    3) Check alignment of spindle

    4) Check trueness of chuck

8. Evaluated to the satisfaction of the instructor

9. Evaluated to the satisfaction of the instructor

10. Evaluated to the satisfaction of the instructor

11. Performance tasks evaluated to the satisfaction of the instructor

PERFORM PRODUCTION RUN
UNIT V

UNIT OBJECTIVE

After completing this unit, the student should be able to perform a production run. The student will show this knowledge by completing assignment sheets and unit test with a minimum score of 85 percent and by performing a production run with a minimum of a 90 percent efficiency rating and a maximum rejection rate of 5 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with production runs to their correct definitions.
2. Calculate efficiency.
3. Calculate productivity.
4. State guidelines to follow in monitoring tool life.
5. Select from a list guidelines to follow in monitoring dimensional accuracy during a production run.
6. Demonstrate the ability to perform production run to required efficiency and productivity standards.
    a. Monitor dimensional accuracy and change offsets as required.
    b. Monitor tool life and change tools as required.

PERFORM PRODUCTION RUN
UNIT V

INSTRUCTIONAL OVERVIEW

I. Unit contents

   A. Objective sheet

   B. Instructional overview (instructor copy)

   C. Instructional supplements (instructor copy)

   D. Information sheet

   E. Assignment sheets

      1. Assignment Sheet #1 — Calculate Efficiency

      2. Assignment Sheet #2 — Calculate Productivity

   F. Answers to assignment sheets (instructor copy)

   G. Job Sheet #1 — Perform Production Run

   H. Test

   I. Answers to test (instructor copy)

II. Suggested activities

   A. Review unit of instruction and plan presentation.

   B. Obtain materials necessary to supplement unit.

   C. Make transparencies.

   D. Introduce students to unit.

   SUGGESTIONS:

   - Tour a plant to observe CNC production equipment in operation; emphasize quality control and productivity measures.

   - Demonstrate a production run in your shop. Show the part the students will be producing.

   - Invite a plant manager to talk to the class about mass production machining, emphasizing how much operating cost must be absorbed in the production of a single part as compared to several thousand.

INSTRUCTIONAL OVERVIEW

D. Provide students with unit of instruction.

E. Discuss unit objectives.

SUGGESTIONS:

- Tell students that they will be applying everything studied in the course up to now in performing their production runs; emphasize the standards set by the unit objective.
- Display and discuss posters regarding productivity, efficiency, and tool safety; relate these to the objectives.
- Have the students organize a project to sell the products machined in this unit; the money can be used for a class party, or to buy shop equipment, etc.

F. Discuss information sheet.

1. Use Section I of the information sheet to discuss terms associated with production machining.

   SUGGESTIONS:

   - Have the students think of examples of the various production measurement terms discussed.
   - Invite a company representative to talk about that company's standard rates and how they impact on other terms listed in the unit.

2. Use Sections II and III of the information sheet to discuss calculating productivity and efficiency.

   SUGGESTIONS:

   - Use numerous examples to make a clear distinction between the two concepts.
   - Refer to previous units for examples of factors that affect productivity and efficiency.

   EXAMPLES: Unit III (the exercise concerning time spent going to the tool room), Unit IV (how tolerance and other factors affect rejection rates)

   - Have students observe beginning operators in other classes and report ways that productivity and efficiency could be improved

INSTRUCTIONAL OVERVIEW

- Invite a panel of machinists and supervisors to discuss steps taken by them and their companies to improve productivity and efficiency.

- Share articles and other information with the students to show comparison between CNC and conventional machining production rates.

- Use Assignment Sheets #1 and #2 to reinforce objectives.

3. Use Section IV of the information sheet to discuss guidelines in monitoring tool life.

SUGGESTIONS:

- Show pictures or share articles comparing tool efficiency while new and after wear.

- Emphasize the effects of abuse in shortening tool life.

4. Use Section V of the information sheet to discuss guidelines in monitoring dimensional accuracy during a production run.

SUGGESTIONS:

- Have students inspect parts labelled in order of production showing the effects of tool wear.

- Emphasize the necessary offset adjustments to cope with changes in dimensional accuracy.

G. Allow students to perform production run.

(NOTE: You may prefer to allow the students to practice a few short runs using Job Sheet #1 or to take turns in a longer run. After a little practice, each student should perform a production run as a part of the test to meet the unit objective standards.)

SUGGESTIONS:

- Observe each student's production run as much as possible so that you may make concrete suggestions for improving productivity and efficiency.

- Have students observe each other to look for ways of improving productivity and efficiency.

INSTRUCTIONAL OVERVIEW

- Allow students to practice inspection techniques by evaluating one another's run for rejection parts.

  (NOTE: You may want to keep the identity of those being inspected anonymous or you may choose to do spot inspections of your own.)

- Invite shop supervisors to observe the students and to evaluate their work.

H. Give test.

I. Reteach and retest if necessary.

PERFORM PRODUCTION RUN
UNIT V

INFORMATION SHEET

I. Terms and definitions

A. Production run — Process of machining several copies of the same part or set of parts

B. Cycle — Act of machining one part during a production run

C. Efficiency — Measure of performance by stating work accomplished as a percentage of predetermined rates

EXAMPLE: If the predetermined rate for producing a bushing is 50 per hour and a worker produces 60 in a one-hour period, that worker is performing at 120% efficiency.

D. Standard rate — Predetermined rate for accomplishing a task; used as the basis for calculating efficiency

(NOTE: Standard rates are usually given as decimal portions of an hour allowed to complete a task — such as 1.2 hours allowed to set up for a part — or as amount of work to be performed in a given length of time — such as producing 50 parts in an hour.)

E. Standard hours — Representative value of time spent by a worker performing tasks that have a standard rate

EXAMPLE: If the standard rate for a part is 0.5 hours (one-half hour), but a technician makes the part in 20 minutes, the worker would have completed 0.5 standard hours because of the production value of what the worker has done.

F. Productivity — Measure of performance by comparing standard hours to total time required from start of a task to completion of that task

G. Actual hours — Time actually spent in the performance of a task or tasks

H. Burden hours (downtime) — Time during which a worker or machine is not performing production tasks during an assigned work period

I. Total time (floor-to-floor time) — Sum of actual hours and burden hours

EXAMPLE: A technician produces 40 parts with a standard rate of 0.125 hours per part during an eight-hour shift. Two hours were spent waiting for material, while six hours were spent actually producing parts.

Standard hours = 40 × 0.125 = 5 hours
Actual hours = 6 hours
Burden hours = 2 hours
Total time = 8 hours

INFORMATION SHEET

J. Tool life — Period that a tool will effectively perform its function

(NOTE: Tool life may be given in terms of time or in terms of number of parts produced. For example, a tool may be said to have a life of two operating hours or, if a given part can be produced at the rate of 50 per hour, that tool's life may be given as 100 parts.)

K. 100% inspection — Check of every dimension of every part produced

L. Spot inspection — Check of a few selected parts of the total produced

II. Calculating efficiency

A. Determine standard rate for task

(NOTE: Work orders state standard rates.)

B. Determine number of times task was performed

C. Calculate standard hours by multiplying standard rate by the number of times the task was performed

D. Determine actual time required to complete task or tasks if it was repeated

E. Calculate efficiency by dividing standard hours by actual hours and multiplying by 100

EXAMPLES: 1. The standard rate for a particular setup is 2.2 hours. A technician completes the task in 2.3 hours. The worker's efficiency for that task is 95.6 percent.

Standard hours = 2.2 × 1 = 2.2 hours
Actual hours = 2.3 × 1 = 2.3 hours
Efficiency = (2.2 ÷ 2.3) × 100 = 95.6%

2. The standard rate for a part is 0.33 hours. A technician produces 14 parts in 4 hours. The worker's efficiency is 115.5 percent.

Standard hours = 0.33 × 14 = 4.62 hours
Actual hours = 4 hours
Efficiency = (4.62 ÷ 4) × 100 = 115.5%

III. Calculating productivity

A. Determine standard rate for task

B. Determine number of times task was performed

INFORMATION SHEET

C. Calculate standard hours by multiplying standard rate by the number of times the task was performed

D. Determine total time spent to complete task or tasks if it was repeated

(NOTE: Productivity is often figured for a specific time period, such as a shift, a month, or a year.)

E. Calculate productivity by dividing standard hours by total time and multiplying by 100

EXAMPLE: A technician spent 5 hours to produce 97 parts with a standard rate of 0.055 hours. During the 8-hour shift, a half hour was spent waiting for materials, 1.5 hours was required for equipment repair, and the technician attended a one-hour safety meeting. For the shift, the worker's productivity was

Standard hours = 0.055 × 97 = 5.3 hours
Total hours = 8 hours
Productivity = (5.3 ÷ 8) × 100 = 66.25%

(NOTE: Under the same circumstances, notice that the efficiency would be 106 percent:
Standard hours = 5.3 hours
Burden hours = 3.0 hours
Actual hours = 5.0 hours
Efficiency = (5.3 ÷ 5) × 100 = 106%.)

IV. Guidelines to follow in monitoring tool life

(NOTE: As cutting tools are used, they wear so that the cutting edges are not as sharp and the cuts become smaller as the edge wears. Thus, worn tools do a worse job of cutting than do sharp tools and eventually will fail to cut at the required depths to met tolerances.)

A. Check tools after every hour of operation for cratering or chipping, burnt edges, and material buildup along cutting edge

(NOTE: Average tool life should be two to three hours *in cut* — that is, the time the tool is actually cutting material.)

B. Observe operation and check parts for signs of tool deterioration

EXAMPLES: Excessive sparking during cut, poor surface finish, increased machining noise

INFORMATION SHEET

C. Replace tools before they become badly worn

(NOTE: Worn tools break easily. A broken tool may embed in the part or otherwise ruin the part. Remember that most companies base their calculation of standard hours on acceptable parts only. Thus, time spent on parts that are out of tolerance is wasted. Also, the technician will often have to replace the tool holder when a tool breaks, lowering productivity and efficiency even more.)

V. Guidelines to follow in monitoring dimensional accuracy during a production run

A. Check each of the first ten parts in a production run to make sure that the setup and tooling are correct and working properly

B. Check every fourth or fifth part after the production is running well

C. Check each dimension with a tolerance of 0.001" or less on each part

(NOTE: Many machinists check one or two dimensions on each part.)

D. Perform part inspections between cycles during production run

(NOTE: Remove the completed part and start the next cycle. While the next part is being run, inspect the completed part. If offsets are required, you will usually have enough time to determine the required offsets while the machine does rough cuts on the next part.)

E. Protect completed parts from damage

(NOTE: A tremendous number of parts must be rejected due to bad threads, poor surface finishes, or other out-of-tolerance conditions because the part was dropped or carelessly tossed onto a work surface after machining was complete. Naturally, damaged parts lower efficiency and productivity.)

PERFORM PRODUCTION RUN
UNIT V

ASSIGNMENT SHEET #1 — CALCULATE EFFICIENCY

NAME ______________________________ SCORE ______________

A company often evaluates a worker's performance in terms of efficiency. Some companies even offer bonuses for high efficiency. A CNC turning technician must understand the concept of efficiency and how to calculate efficiency in order to weigh job opportunities and as a tool in evaluating performance.

Read each situation below and calculate the efficiency. Show your answer to the nearest one-tenth of a percent.

A. A turning technician produces fourteen splined shafts in a two-hour period. What was the technician's efficiency rating if the standard rate for the part was 0.118 hours?

Efficiency = ______________________

B. Another technician worked for 7.5 hours to produce 29 pulleys. What was her efficiency if the standard rate was 0.293 hours per pulley?

Efficiency = ______________________

ASSIGNMENT SHEET #1

C. A setup person completed a setup in 1.3 hours. What was his efficiency if the standard rate for the task was 1.1 hours?

Efficiency = ______________________________

D. A CNC turning technician was assigned to make 50 hydraulic cylinder pistons with a standard rate of 0.25 hours.

1. The technician inspects each of the first ten parts and makes some machine adjustments. It takes 3.7 hours to do the first ten parts. What was the worker's efficiency?

   Efficiency = ______________________________

ASSIGNMENT SHEET #1

2. It takes the worker 7.4 hours to do the rest of the pistons. What was his efficiency for the 40 pistons in 7.4 hours?

Efficiency = ____________________________

3. What was the technician's overall efficiency for all 40 pistons?

Efficiency = ____________________________

PERFORM PRODUCTION RUN
UNIT V

ASSIGNMENT SHEET #2 — CALCULATE PRODUCTIVITY

NAME ____________________ SCORE ____________

Much of a CNC technician's time is spent in activities other than operating equipment. Equipment downtime, setup, waiting for materials or tools, and other delays lower productivity. In fact, many companies try to improve productivity by having specialists for each phase of production. The technician needs to understand how individual efficiencies and other factors relate to productivity in order to improve planning and performance and to appreciate the many considerations in the successful operation of a company.

Read the situations below and calculate productivity for each case. Show your answer to the nearest one-tenth of a percent.

A. A slotted sleeve has a standard rate of 0.413 hours. During one particular eight-hour shift, the coolant pump goes out on a machine and requires five hours for replacement. What is the technician's productivity for the shift if six sleeves were produced?

Productivity = ____________________

B. A technician assigned to produce threaded shaft caps is gone from the plant for a doctor's appointment and misses an hour of the eight-hour shift. While on the job she produces 120 caps. What is her productivity if the work order lists a standard rate of 0.056 hours per part?

Productivity = ____________________

ASSIGNMENT SHEET #2

C. A company tests a new CNC lathe by manufacturing a test piece for a 40-hour work week. During that period, the machine is down for repairs a total of 9.3 hours. What productivity rating is achieved if the test piece has a standard rate of 0.388 and 105 parts are produced?

Productivity = ______________________________

D. A technician spends an entire eight-hour shift producing 32 spindle brackets. During the shift, he loses 30 minutes because of a power outage. Three of the brackets fail to pass tolerance inspections and are not counted toward his production. What was the technician's productivity for the shift if the bracket has a standard rate of 0.293 hours?

Productivity = ______________________________

ASSIGNMENT SHEET #2

E. A company is interested in bidding a contract to provide bushing collars for a manufacturer. In figuring the bid the company notes that during the past year, downtime has averaged 1.3 hours per eight-hour shift for the machines and operators who would be involved in the project. What kind of productivity rate could the company expect if the technicians produced at 100% efficiency?

Productivity = ________________________

PERFORM PRODUCTION RUN
UNIT V

ANSWERS TO ASSIGNMENT SHEETS

(NOTE: Due to differences in rounding off during calculations, count as correct any answer within ±0.1.)

Assignment Sheet #1

A. 82.6%

B. 113.3%

C. 84.6%

D. 1. 67.5%
   2. 135.1%
   3. 112.6%

Assignment Sheet #2

A. 30.9%

B. 95.7%

C. 101.8%

D. 114.1%

E. 83.8%

PERFORM PRODUCTION RUN
UNIT V

JOB SHEET #1 — PERFORM PRODUCTION RUN

I. Equipment and materials

- A. CNC lathe
- B. Operator's manual
- C. Work order and setup sheet
- D. Tools required by setup sheet
- E. Materials required for part

  (NOTE: You should have available enough material to produce the number of parts required.)
- F. Shop towels
- G. Standard sets of tools and inspection equipment for lathe operations

II. Procedure

- A. Perform routine maintenance inspection of machine if required
- B. Review setup sheet and work order
- C. Prepare work station for production
- D. Power up machine
- E. Set up jaws
- F. Load program if required
- G. Move U and W slides to program home position
- H. Determine initial offsets and store in control
- I. Test run and edit program if necessary
- J. Edit program and change setup as required
- K. Run and evaluate next nine parts, editing program and changing setup as required
- L. Continue production

JOB SHEET #1

M. Inspect parts as necessary during production run

(NOTE: Check dimensions with a tolerance of 0.001" on each part. Perform spot check on every fourth or fifth part.)

1. Remove completed part from machine after cycle
2. Load next workpiece and start cycle
3. Inspect completed part
4. Make offsets as required

N. Monitor tool life

O. Replace tools as necessary

1. Allow program to complete cycle for worn tool
2. Index turret to allow access to tool
3. Replace tool insert if required
    a. Remove insert
    b. Clean holder
    c. Install new insert and tighten pin and clamp until snug

       (CAUTION: Do not overtighten.)

    d. Adjust X offset 0.002" to 0.003" to allow for wear in old insert
4. Replace drill or end mill, if required
    a. Measure distance from tip of tool to face of holder
    b. Remove tool from holder
    c. Sharpen tool if required
    d. Insert new or sharpened tool in holder
    e. Adjust tool to previous setting and tighten

       (NOTE: If the tool cannot be adjusted to the measured length, adjust Z offset to allow for difference.)

JOB SHEET #1

5. Rerun tool after each tool change and adjust offsets or setup as required.

P. Handle and store completed parts carefully to prevent damage

Q. Run required number of parts

(NOTE: It is a courteous practice to notify your supervisor about thirty minutes prior to completing a production run so that another job may be readied for you.)

R. Clean up area and tools as required and prepare for next procedure

S. Shut down machine if no longer required

PERFORM PRODUCTION RUN
UNIT V

TEST

NAME ________________________________ SCORE ______________

1. Match terms associated with production runs to their correct definitions. Write the correct numbers in the blanks.

_____a. Process of machining several copies of the same part or set of parts

_____b. Act of machining one part during a production run

_____c. Measure of performance by stating work accomplished as a percentage of predetermined rates

_____d. Predetermined rate of accomplishing a task; used as the basis for calculating efficiency

_____e. Representative value of time spent by a worker performing tasks that have a standard rate

_____f. Measure of performance by comparing standard hours to total time required from the start of a task to the completion of that task

_____g. Time actually spent in the performance of a task or tasks

_____h. Time during which a worker or machine is not performing production tasks during an assigned work period

_____i. Sum of actual hours and burden hours

_____j. Period that a tool will effectively perform its function

_____k. Check of every dimension of every part produced

_____l. Check of a few selected parts of the total produced

1. Efficiency
2. Actual hours
3. Spot inspection
4. Production run
5. Total time
6. Standard rate
7. Cycle
8. Burden hours
9. Productivity
10. 100% inspection
11. Tool life
12. Standard hours

TEST

2. Calculate efficiency. A technician produces 23 parts in a four-hour period. What efficiency rating is achieved if the standard rate of the part is 0.210 hours per part?

Efficiency = ______________________________

3. Calculate productivity. A technician finishes 104 parts during an eight-hour shift. During the shift, 1.2 hours is lost to equipment repairs and one-half of an hour is spent waiting for materials. What is the worker's productivity if the standard rate for the part is 0.062 hours per part?

Efficiency = ______________________________

4. State guidelines to follow in monitoring tool life. Write the guidelines in the spaces provided.

a. ____

____

____

b. ____

____

____

TEST

c. ______________________________

____

____

5. Select from a list guidelines to follow in monitoring dimension accuracy during a production run. Write an "X" beside each correct guideline.

_____a. Check each of the first ten parts in a production run to make sure that the setup and tooling are correct and working properly

_____b. Check every fortieth or fiftieth part after the production is running well

_____c. Check each dimension with a tolerance of 0.100" or less on each part

_____d. Perform part inspections between cycles during production run

_____e. Protect completed parts from damage

6. Demonstrate the ability to perform a production run.

(NOTE: See your instructor if you have not performed a production run for evaluation.)

PERFORM PRODUCTION RUN
UNIT V

ANSWERS TO TEST

1. a. 4
   b. 7
   c. 1
   d. 6
   e. 12
   f. 9
   g. 2
   h. 8
   i. 5
   j. 11
   k. 10
   l. 3

2. 120.7%

3. 80.7%

4. a. Check tools after every hour of operation for cratering or chipping, burnt edges, and material buildup along cutting edge

   b. Observe operation and check parts for signs of tool deterioration

   c. Replace tools before they become badly worn

5. a, d, e

6. Performance skills evaluated to the satisfaction of the instructor

WRITE A PROGRAM
UNIT VI

UNIT OBJECTIVE

After completing this unit, the student should be able to write a program. The student will show this knowledge by completing assignment sheets, and unit test with a minimum score of 85 percent and writing a program to produce a part having at least two outside diameters and one inside diameter.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with writing a program to their correct definitions.
2. State purpose of the program.
3. Match program letters to their basic functions.
4. Match G codes to their modes of operation.
5. Match M codes to their functions.
6. Select from a list steps to draw part from blueprint for program planning.
7. Calculate X and Z values using absolute method.
8. Calculate X and Z values using incremental method.
9. Calculate X and Z values using tool radius compensation
10. Calculate I and K values.
11. Select from a list steps to determine threading passes.
12. Select from a list factors to consider when selecting tooling required for a procedure.
13. Select from a list guidelines for planning procedure.
14. Calculate speeds and feeds.
15. Arrange in order steps in writing a program.
16. Select from a list steps in writing a program to cut dwell.
17. Distinguish between steps in writing a program for threading.

OBJECTIVE SHEET

18. Plan procedure.
19. Complete a setup sheet.
20. Write a program.

WRITE A PROGRAM
UNIT VI

INSTRUCTIONAL OVERVIEW

I. Unit contents

- A. Objective sheet
- B. Instructional overview (instructor copy)
- C. Instructional supplements (instructor copy)
- D. Information sheet
- E. Assignment sheets
  1. Assignment Sheet #1 — Draw Part from a Blueprint
  2. Assignment Sheet #2 — Calculate Point Values from a Drawing
  3. Assignment Sheet #3 — Plan Procedure
  4. Assignment Sheet #4 — Calculate Speeds and Feeds
  5. Assignment Sheet #5 — Complete a Setup Sheet
  6. Assignment Sheet #6 — Write a Program
- F. Answers to assignment sheets (instructor copy)
- G. Test
- H. Answers to test (instructor copy)

II. Suggested activities

- A. Review unit and plan presentation.

  (NOTE: The unit contains five assignment sheets which provide practice problems in learning the program writing procedure and a sixth assignment sheet for actually writing a program. The first five assignment sheets provide space for the student to complete the assignment sheet activity for the part the student is writing a program for. You may wish to have the students complete the practice portion of the assignment sheets and evaluate them before letting the students complete the work for their projects.)

- B. Obtain and prepare materials needed to supplement unit.
- C. Provide students with copies of unit.

INSTRUCTIONAL OVERVIEW

D. Introduce unit to students.

SUGGESTIONS:

- Invite a programmer to talk to the class about that type of work.
- Have the students select a set of blueprints for a part for them to use in writing a program.
- Review the skills acquired in the previous units and relate them to the job of programming.

E. Discuss unit and specific objectives.

SUGGESTIONS:

- Introduce unit by showing students the machine and actually producing a part.
- Be prepared to input program into the machine and actually produce a part.

F. Discuss information sheet.

1. Use Section I of the information sheet to teach terms and definitions.

   SUGGESTIONS:

   - Use a setup sheet to share with students when terms apply.
   - Use examples of parts and equipment to create concrete meanings for students.

2. Use Section II of information sheet to teach the purpose of a program.

   SUGGESTIONS:

   - Show a piece of rolled stock cut to the correct dimensions of a particular part and a blueprint for the part and a completed part to help students to recognize the importance of a program.
   - Run one block of a program and explain the block entries in detail.

3. Combine Sections III, IV, and V of information sheet to teach the functions and modes of operations of the CNC machine.

   SUGGESTIONS:

   - Make sure that students realize that G codes designate modes of operation and that M codes perform certain machine functions.
   - Write selected G and M codes on chalkboard and have students designate modes of operations or functions.

INSTRUCTIONAL OVERVIEW

4. Use Section VI of information sheet to discuss drawing a part from a blueprint.

   SUGGESTIONS:

   - Show students a blueprint with a part detailed to specifications.
   - Show students a technician's drawing of a part and encourage students to use the industry standard as a goal while drawing their part.
   - Use Assignment Sheet #1 to reinforce the objectives.

5. Use Sections VII through X of information sheet to help students to calculate point values.

   SUGGESTIONS:

   - Show a part and identify the different points to illustrate the meaning of point values.
   - Use a variety of drawings with the points identified and have students calculate values.
   - Use Assignment Sheet #2 to reinforce objectives.

6. Use Section XI of information sheet to discuss the procedure to determine thread passes.

   SUGGESTIONS:

   - Depending on the background and experience of your students, you may want to go into greater detail in threading. For example, you may want to discuss angular end feed and other principles.
   - Provide students with various threaded parts and with standard thread design charts.
   - Emphasize the relationships between the various elements of a thread and how the use of standard designs allows for a great deal of automatic threading with CNC equipment.

7. Use Section XII of information sheet to help students select tooling for a program.

   SUGGESTIONS:

   - Stress the importance of selecting the correct tool for a job since the program cannot be written until the tooling has been correctly

INSTRUCTIONAL OVERVIEW

selected.

- Show examples of different tools and discuss their function(s) and purpose(s) in program.
- Use Assignment Sheet #3 to reinforce objective.
- Display programs requiring several tools and ask students to name the first tool that would be used.
- Invite a setup person to explain to the class details of that type of work.

8. Use Section XIII of the information sheet to discuss planning procedures.

   SUGGESTIONS:

   - Provide students with blueprints or parts to allow them to practice identifying operations.
   - Discuss the consequences of doing steps in an incorrect order; relate sequencing to the discussion of productivity and efficiency in Unit V.
   - Use Assignment Sheet #3 to reinforce objective.

9. Use Section XIV of information sheet to help students to calculate speeds and feeds.

   SUGGESTIONS:

   - Provide examples of speeds and feeds to illustrate their functions during the operation of a program.
   - Use chalkboard and discuss formulas; help students to work examples of problems.
   - Use Assignment Sheet #4 to reinforce objective.

10. Use Section XV of information sheet to discuss writing a program.

    SUGGESTIONS:

    - Show students a completed program to stress the importance of selecting the correct codes. Show results of errors made.
    - Use Assignment Sheets #5 and #6 to reinforce objective.

INSTRUCTIONAL OVERVIEW

11. Use Section XVI of information sheet to discuss dwell and programming for dwell.

    SUGGESTIONS:

    - Show parts or prints requiring dwell cuts.
    - Show examples of parts with inaccurate thread cuts--too long or too short.
    - Demonstrate a dwell cut.

12. Use Section XVII of information sheet to discuss programming for threads.

    (NOTE: You may wish to break this into two lessons, one covering G32 and one covering G92. Using G32 to program and operate the machine provides the student with a better understanding of the threading process and allows practice in designing detail into a program. Once these skills have been mastered, the students can appreciate the convenience of the G92 code.)

    SUGGESTIONS:

    - Review Section XI of information sheet to reinforce student's understanding of procedure.
    - Demonstrate the use of each code.
    - Provide students with threaded part prints to allow practice in determining start and stop points and in writing programs for threading.

    (NOTE: This is especially important for students who are writing programs that do not require threading operations.)

G. Give test.

(NOTE: A part of each student's test should be a run of the program written by that student.)

H. Reteach and retest if necessary.

WRITE A PROGRAM
UNIT VI

INFORMATION SHEET

I. Terms and definitions

A. Data block — One line of information to cause motion or to convey information to control

B. Sequence number — Word address for numbering data blocks

C. Program — Group of instructions that causes specific machine actions

(NOTE: The program relays all machine functions and actions to the control in the order they are to take place.)

D. Manuscript — Handwritten program sheet

E. Readout — Sheet showing all codes and instructions for a program

F. Datum point — Point of origin for program; X0, Z0

G. Canned cycle — Predetermined series of motions for a tool path

H. Multiple repetitive cycle — Command for doing a repetitive series of fixed motions

II. Purpose of program — To create a finished part machined to blueprint specifications from a piece of unfinished material

III. Program letters and their basic functions

A. N — Denotes the sequence numbers for all data blocks

(NOTE: All N codes are followed by four digits.)

B. G — Sets the mode of operation for preparatory functions

(NOTE: All G codes are followed by two digits.)

C. X — Specifies X-axis position

D. Z — Specifies Z-axis position

E. U — Specifies incremental positioning of X-axis

F. W — Specifies incremental positioning of Z-axis

G. I — Denotes arc center offset for X-axis

INFORMATION SHEET

H. K — Denotes arc center offset for Z-axis

I. F — Indicates feed rate selection

J. R — Indicates radius length of arc

K. S — Indicates spindle speed selection

L. T — Indicates tool and offset selection

M. M — Indicates miscellaneous functions

IV. G codes and their modes of operation

A. Universal control codes

1. G00 — Rapid traverse
2. G01 — Linear interpolation
3. G02 — Clockwise circular interpolation
4. G03 — Counterclockwise circular interpolation
5. G04 — Dwell
6. G20 — Inch mode
7. G21 — Metric mode
8. G27 — Zero return check (home check)
9. G28 — Automatic zero return (automatic home)
10. G32 — Threading, single pass
11. G40 — Cutter radius compensation off
12. G41 — Cutter radius compensation left
13. G42 — Cutter radius compensation right
14. G50 — Preset position register
15. G70 — Finish cycle for multiple repetitive cycles (G71,G72,G73)
16. G71 — Multiple repetitive roughing cycle for longitudinal turning
17. G72 — Multiple repetitive roughing cycle for facing cuts

INFORMATION SHEET

18. G73 — Multiple repetitive roughing cycle for contouring cuts

19. G74 — O.D. grooving cycle

20. G75 — Face grooving cycle

21. G76 — Multiple repetitive threading cycle

22. G90 — Canned cycle for longitudinal turning (single pass)

23. G92 — Canned cycle for threading (single pass)

24. G94 — Canned cycle for facing cuts (single pass)

25. G96 — SFM designation for spindle speed

26. G97 — RPM designation for spindle speed

27. G98 — IPM

28. G99 — IPR

B. American control codes

(NOTE: Most American control codes do not have the canned and multiple repetitive cycles.)

1. G33 — Threading

2. G70 — Inch mode

3. G71 — Metric mode

4. G90 — Absolute

5. G91 — Incremental

6. G92 — Home preset

7. G94 — IPM

8. G95 — IPR

V. M codes and their functions

A. M00 — Program stop

B. M01 — Optional stop

C. M02 — Program end

D. M03 — Spindle on forward (CW)

INFORMATION SHEET

E. M04 — Spindle on reverse (CCW)

F. M05 — Spindle off

G. M08 — Coolant on

H. M09 — Coolant off

I. M30 — Program end—rewind stop

J. M65 — O.D. Chucking

K. M66 — I.D. Chucking

L. M98 — Subroutine call

M. M99 — Subroutine return

VI. Steps to draw part from blueprint for program planning

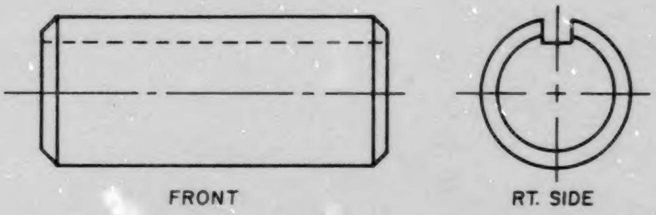
A. Study blueprint

B. Select view that shows most significant dimensions for operation to be done

(NOTE: For most CNC lathe operations, the front view on the blueprint will show most of the significant dimensions in turning. See Figure 1.)

EXAMPLE:

FIGURE 1



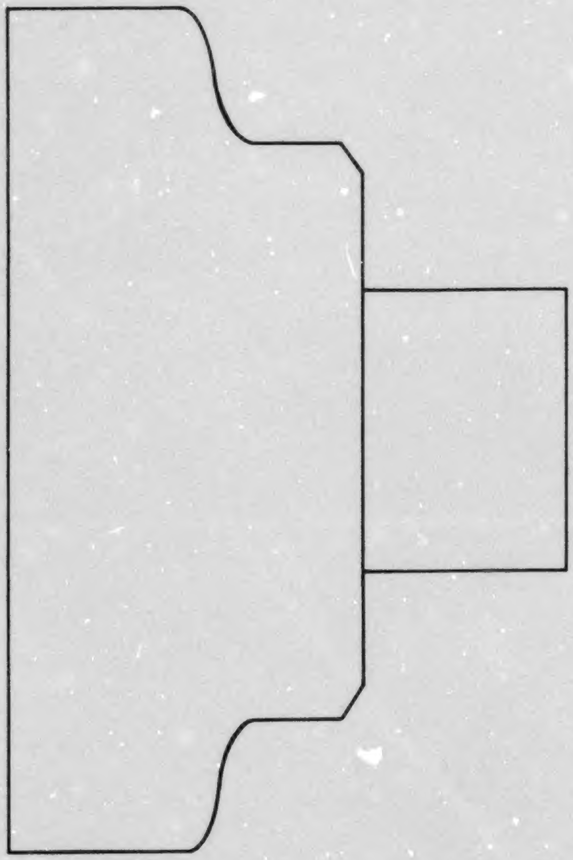
INFORMATION SHEET

C. Draw a profile of the part with the chucked end to the left (Figure 2)

(NOTE: For this drawing it is not necessary to show hidden lines, edges, or other details. At this point you are only interested in the general shape of the part.)

EXAMPLE:

FIGURE 2



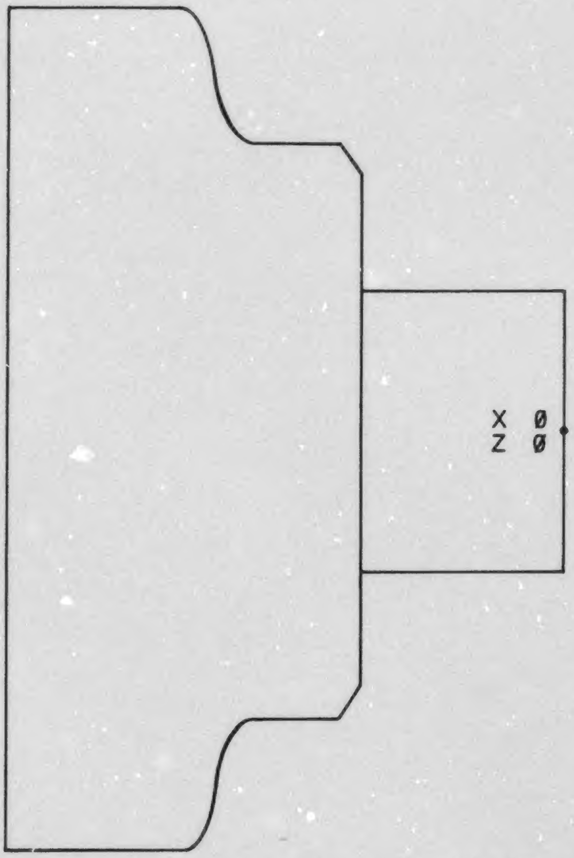
INFORMATION SHEET

D. Label datum point (Figure 3)

(NOTE: The datum point will be at the centerline on the right face. The datum point will serve as the starting reference for X and Z values.)

EXAMPLE:

FIGURE 3



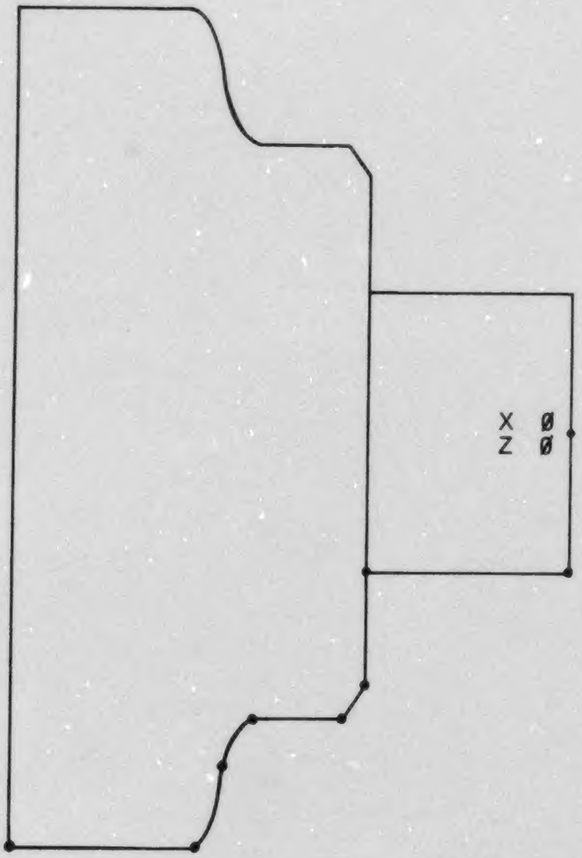
INFORMATION SHEET

E. Place a dot at each point where lines intersect on one half of the drawing (Figure 4)

(NOTE: The dots indicate the start and stop points of the finish tooling. Only half need be labeled because tool travel will be along one surface as the part is machined. The other half may be used to indicate rough cuts.)

EXAMPLE:

FIGURE 4



(NOTE: Notice that dots are placed at points where curved lines intersect other curved or straight lines, such as shown for the radius in the example.)

INFORMATION SHEET

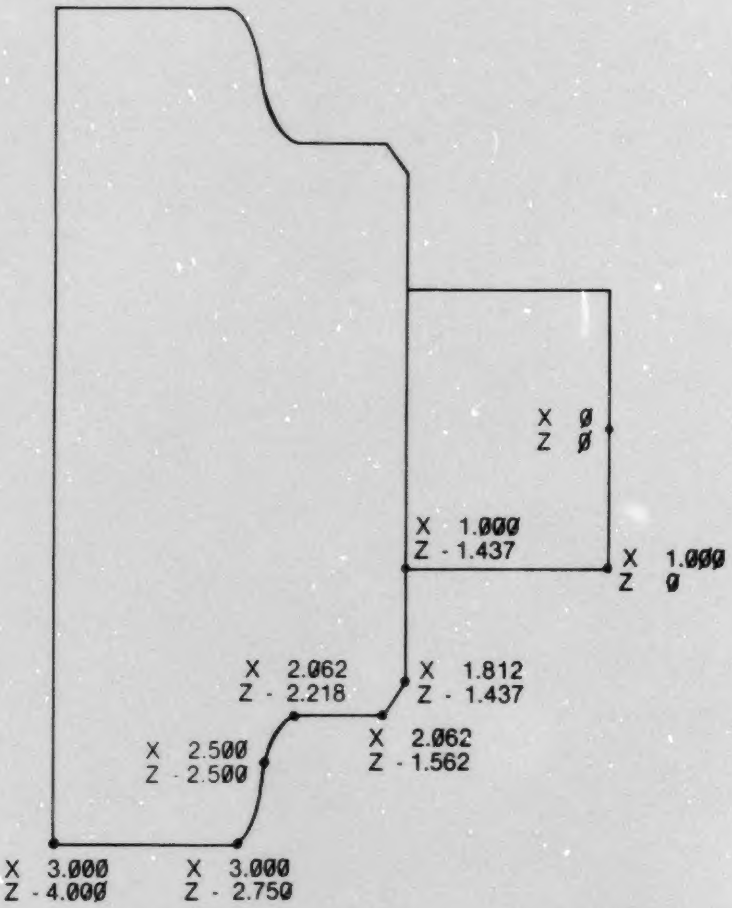
F. Determine the X and Z values for each point

(NOTE: The methods of determining X and Z values are described later in this unit.)

G. Label the points with their X and Z values (Figure 5)

EXAMPLE:

FIGURE 5


X 0
Z 0
X 1.000
Z - 1.437
X 1.000
Z 0
X 2.062
Z - 2.218
X 1.812
Z - 1.437
X 2.500
Z - 2.500
X 2.062
Z - 1.562
X 3.000
Z - 4.000
X 3.000
Z - 2.750

INFORMATION SHEET

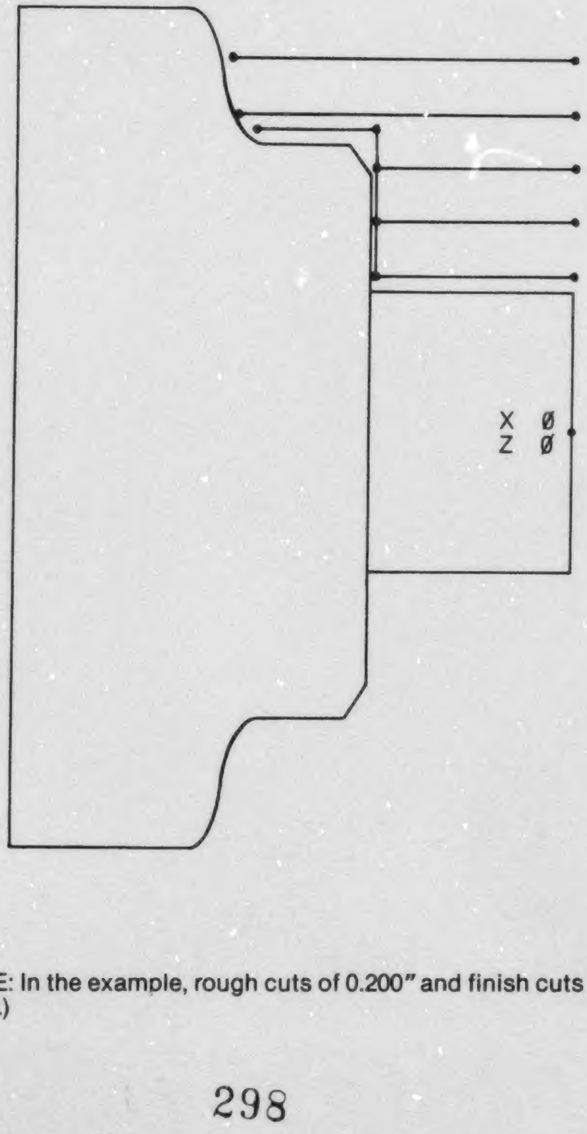
H. Determine rough and finish depths of cuts

I. Make another drawing of the part profile or use other half of first drawing

J. Add lines to the drawing to represent each rough cut; place a dot at each end of each rough cut line (Figure 6)

EXAMPLE:

FIGURE 6



(NOTE: In the example, rough cuts of 0.200" and finish cuts of 0.030" will be made.)

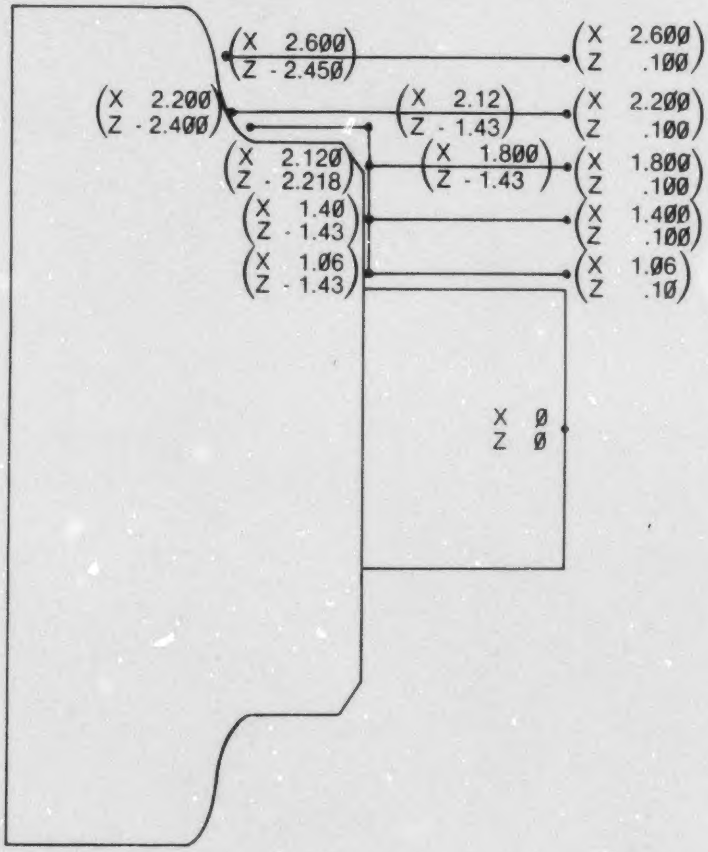
INFORMATION SHEET

K. Calculate the X and Z values for the starting point and end of each rough cut

L. Label the X and Z values of the rough cuts (Figure 7)

EXAMPLE:

FIGURE 7

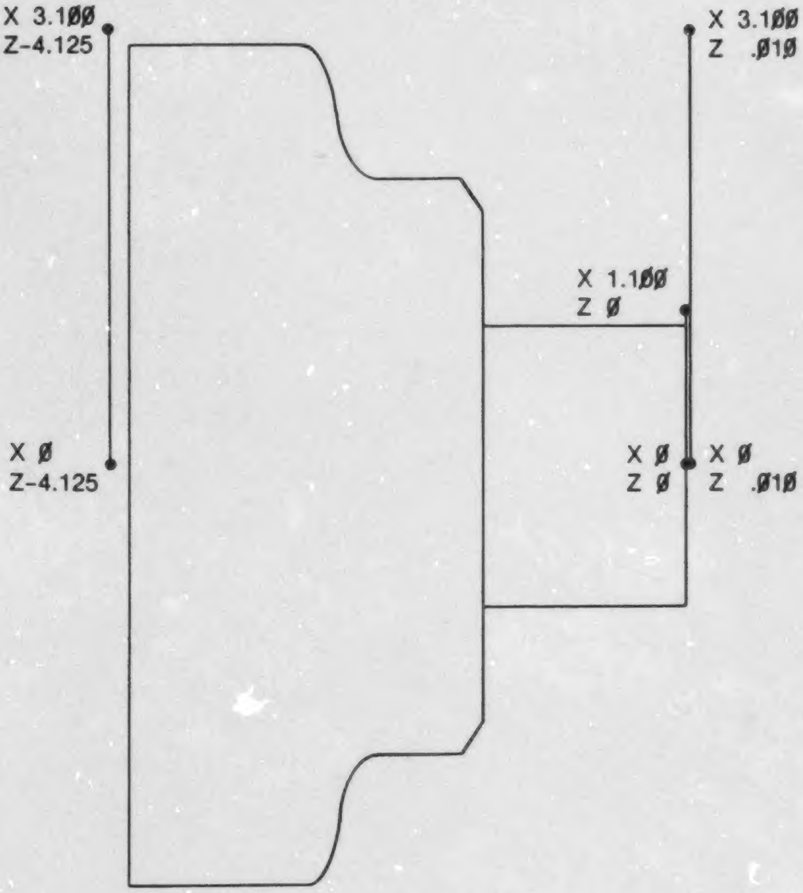

X 2.600
Z -2.450
X 2.600
Z .100
X 2.200
Z -2.400
X 2.12
Z -1.43
X 2.200
Z .100
X 2.120
Z -2.218
X 1.800
Z -1.43
X 1.800
Z .100
X 1.40
Z -1.43
X 1.400
Z .100
X 1.06
Z -1.43
X 1.06
Z .10
X 0
Z 0

INFORMATION SHEET

M. Repeat the procedure to produce labeled drawings for other required machining operations, such as drilling holes, cutting off part, etc. (Figure 8)

EXAMPLE:

FIGURE 8



VII. Procedure for calculating X and Z values using absolute method

A. Label datum point $\frac{X\ 0.0}{Z\ 0.0}$

B. Review blueprint and determine diameter of face on which datum point is located

C. Determine mean dimension if necessary

EXAMPLE: The tolerances on the face diameter of the part used as an example in Section VI are $\frac{1.002}{0.998}$; thus, the mean dimension is 1.000".

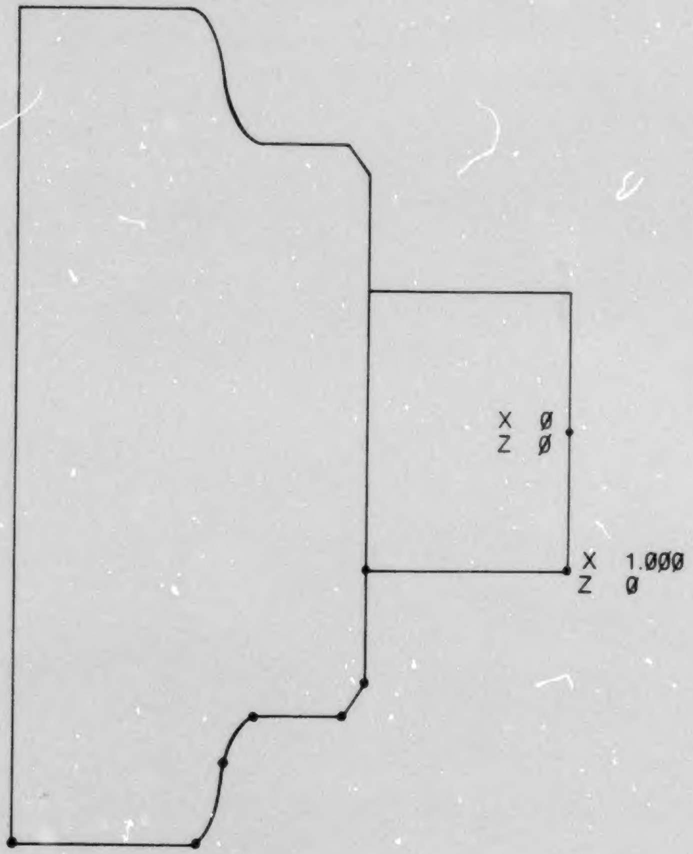
INFORMATION SHEET

D. Label the X and Z values for the first point (Figure 9)

(NOTE: The first point will have an X value equal to the diameter of the face and a Z value of 0.0. Remember that X values are equal to the part diameter.)

EXAMPLE:

FIGURE 9



E. Repeat steps B and C to determine the X value of the second point based on the diameter at that point

EXAMPLE: The second point in the example being used is the junction of the shoulder and the smallest diameter. The diameter at this point is the same as the face, so the X value is the same: X 1.000.

INFORMATION SHEET

F. Determine the distance of travel along the Z axis between the first and second points as shown on the print

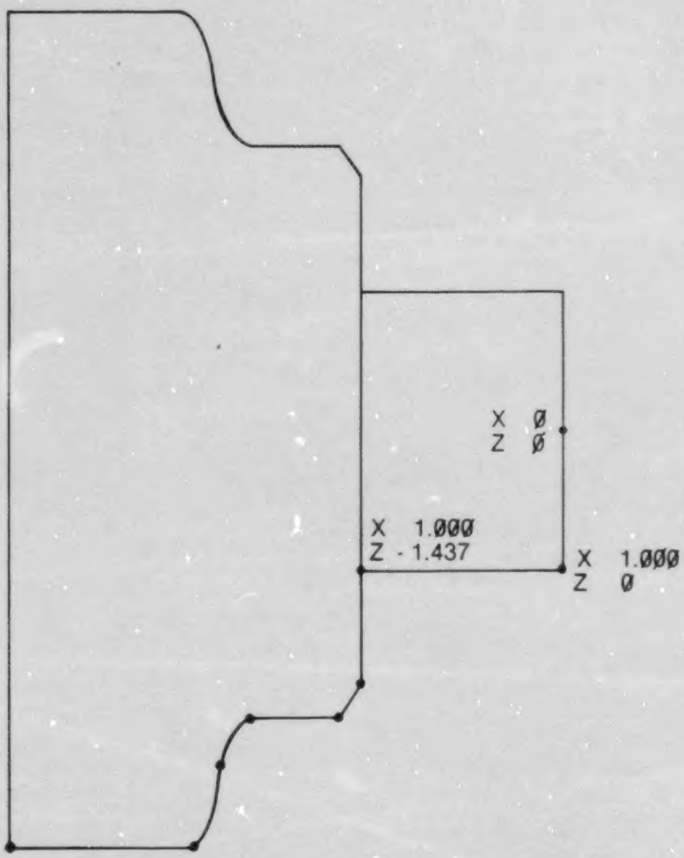
EXAMPLE: The blueprint for the part shows that the face is 1.437" from the shoulder.

G. Determine mean dimension if necessary

H. Label X and Z values of second point (Figure 10)

EXAMPLE:

FIGURE 10

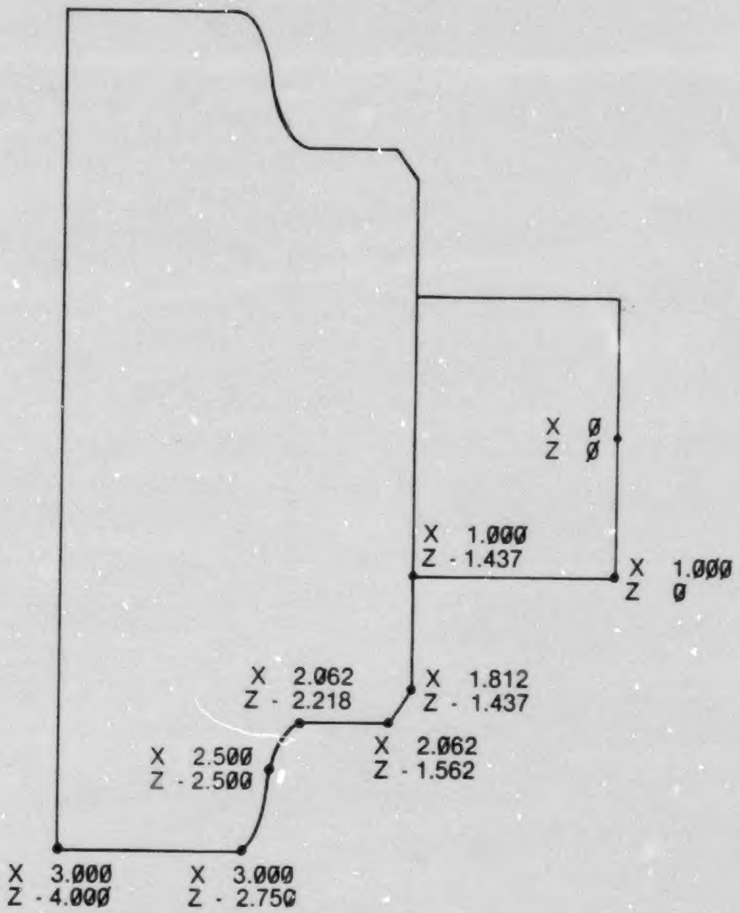


(NOTE: Lathe tools normally travel in a -Z direction for machining. As diameters increase, travel is in a +X direction; as diameters decrease, travel is in a -X direction.)

INFORMATION SHEET

I. Continue procedure to label remaining points based on mean dimensions of diameters (Figure 11)

FIGURE 11

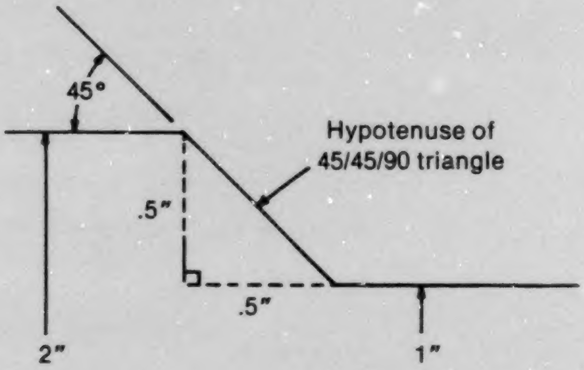

X 0
Z 0
X 1.000
Z - 1.437
X 1.000
Z 0
X 2.062
Z - 2.218
X 1.812
Z - 1.437
X 2.500
Z - 2.500
X 2.062
Z - 1.562
X 3.000
Z - 4.000
X 3.000
Z - 2.750

INFORMATION SHEET

(NOTE: X and Z values are based on travel along those two axes. However, during machining, tool travel may not follow the X and Z axes exactly as in the case of tapers, threads, grooves, and radii. Yet the X and Z values for any point in the profile drawing can be determined by applying common geometric formulas. See the examples below.)

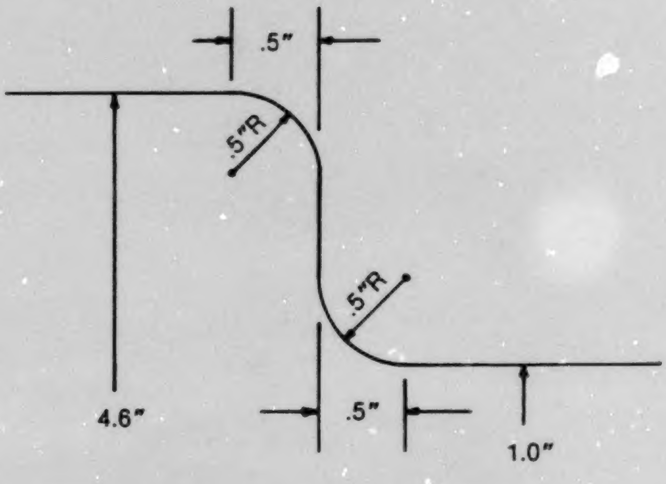
EXAMPLES:

FIGURE 12



(NOTE: Use trigonometric functions or the Pythagorean theory to determine dimensions of angles, chamfers, and tapers.)

FIGURE 13



(NOTE: Basic geometric and trigonometric formulas can be used to figure dimensions in relation to curved lines. See Section IX.)

INFORMATION SHEET

VIII. Calculating X and Z values using incremental method

(NOTE: When using the incremental method, the U and W registers are used.)

A. Review print

B. Determine U and W distances to destination point from current point

C. Subtract U distance of current point from U distance of destination point

D. Subtract W distance of current point from W distance of destination point

EXAMPLE: Using the edge of the face as the current point and the chamfered shoulder as the destination, the X axis must travel (Figure 14)

= (U distance destination) – (U distance current point)

= 1.000 – 1.000

= 0

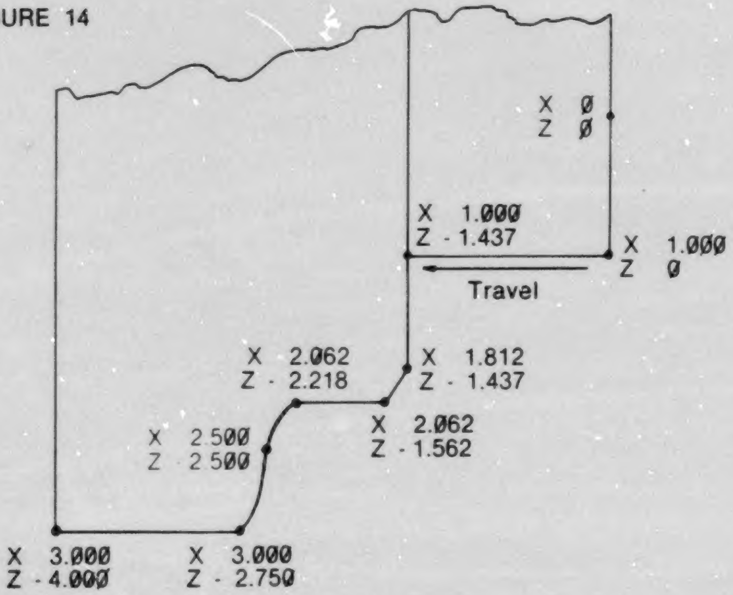
The Z axis must travel

= (W distance destination) – (W distance current point)

= -1.437 – 0

= -1.437

FIGURE 14


X 0
Z 0
X 1.000
Z - 1.437
X 1.000
Z 0
Travel
X 2.062
Z - 2.218
X 1.812
Z - 1.437
X 2.062
Z - 1.562
X 2.500
Z 2.500
X 3.000
Z - 4.000
X 3.000
Z - 2.750

INFORMATION SHEET

IX. Calculating X and Z values using tool radius compensation

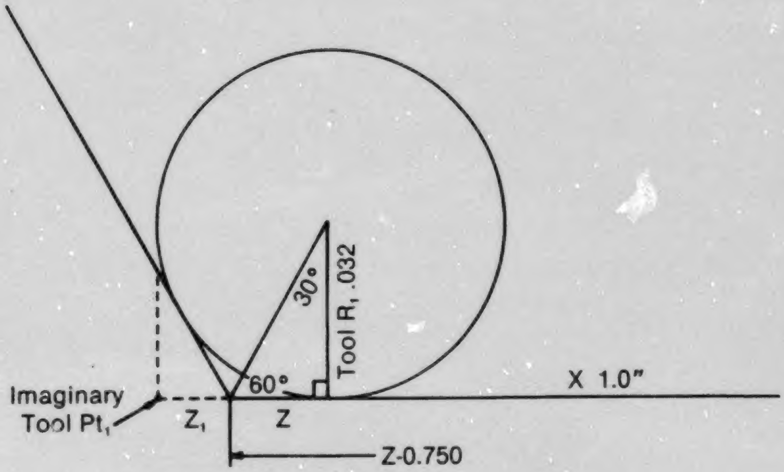
(NOTE: Tool radius compensation is required because cutting tools have a rounded point instead of a sharp point which causes material to be left on the radii and chamfers.)

A. Procedure for angle between surfaces

1. Determine tool radius (R_T)
2. Determine angle between surfaces
3. Determine Z value for print intersection
4. Adjust Z value for program
    a. Determine angle between tool center and intersection of surfaces when tool radius is tangent to both surfaces
    b. Determine tangent of angle (Figure 15)

EXAMPLE:

FIGURE 15



INFORMATION SHEET

c. Calculate distance between tangent point and intersection point tangent by tool radius

EXAMPLE: $Z = (\text{Tangent} <) \times R_T$

$= (\text{Tangent } 30) \times .032$

$= .577 \times .032$

$= .0184$

d. Calculate Z_1 distance from intersection point to the imaginary tool point (PT_1) by subtracting Z value from tool radius

EXAMPLE: $Z_1 = R_T - Z$

$= .032 - .0184$

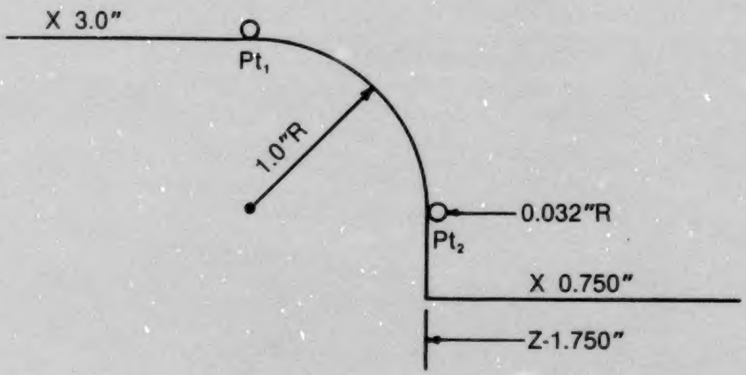
$= .0136$

B. Procedure for curved surfaces (Figure 16)

1. Determine tool radius (R_T)
2. Determine part radius (R_P)
3. Determine program radius (R_{PR}) by adding the tool radius and the part radius

EXAMPLE:

FIGURE 16



$R_{PR} = R_T + R_P$

$= .032 + 1.00$

$= 1.032$

INFORMATION SHEET

4. Change X and Z values at known points by program radius

(NOTE: You may have to add or subtract the program radius, depending on the radius and the known locations.)

EXAMPLES: Point 1
X = 3.0
Z = (Z at Pt_2) − (R_{PR})
= 1.750 − 1.032
= −2.782
Pt_1 = X 3.0
Z −2.782

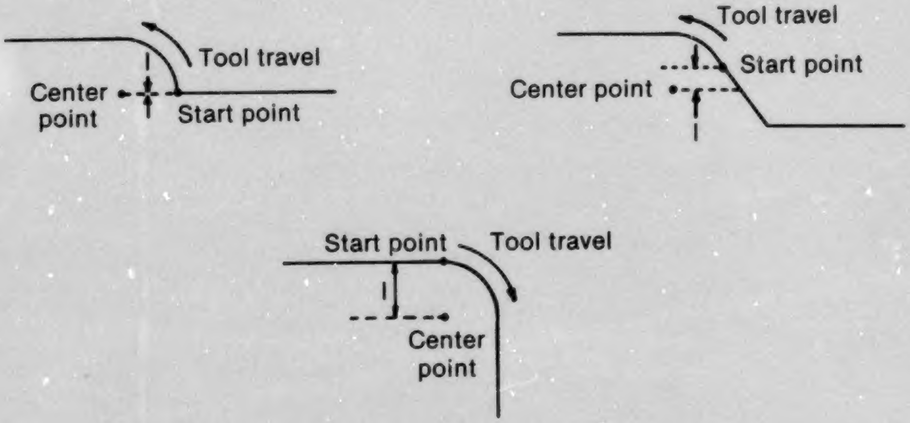
Point 2
X = (X at Pt_1) − (R_{PR})
= 3.0 − 1.032
= 1.968
Z = −1.750
Pt_2 = X 1.968
Z −1.750

X. Calculating I and K values

(NOTE: When programming an arc or radius, the operator must tell the control what the radius is. In the case of most CNC controls this is done by using *I* and *K* values to tell the control where the center point is in relation to the start point.)

A. *I* tells the control the distance from the start point to the center point in the X axis only (Figure 17)

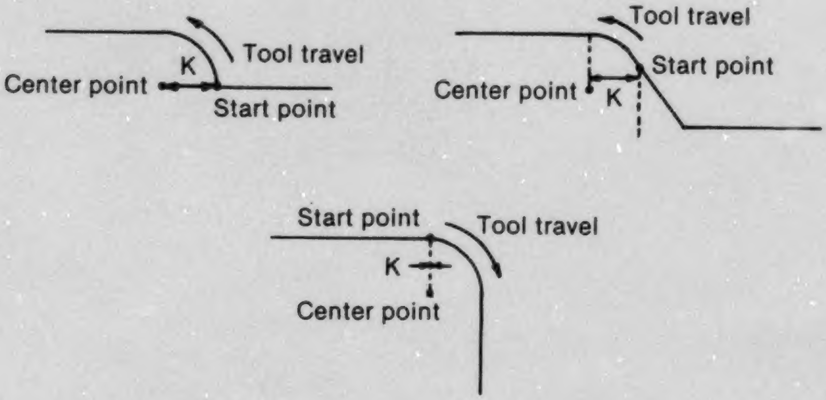
FIGURE 17


Tool travel
I
Center point
Start point
Tool travel
Start point
Center point
I
Start point
Tool travel
I
Center point

INFORMATION SHEET

B. *K* tells the control the distance from the start point to the center point in the Z axis only (Figure 18)

FIGURE 18


Tool travel
K
Center point
Start point
Tool travel
Start point
Center point
K
Start point
Tool travel
K
Center point

C. To calculate I, use the formula

I = (X center) – (X start)

EXAMPLE: For the part discussed in Section VII, the *I* value for the first radius would be

I = (X center) – (X start)

= 2.500 – 2.062

= 0.438

D. To calculate K, use the formula

K = (Z center) – (Z start)

EXAMPLE: For the part discussed in Section VII, the *K* value for the first radius would be

K = (Z center) – (Z start)

= (-2.218) – (-2.218)

= (-2.218) + (2.218)

= 0

(NOTE: If an *I* or *K* value is zero, there is no need to enter it into the program.)

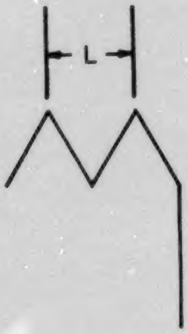
INFORMATION SHEET

X. Steps to determine threading passes

A. Determine lead (L) of thread (Figure 19)

(NOTE: Use the formula $L = \frac{1}{\text{\# of threads/inch}}$.)

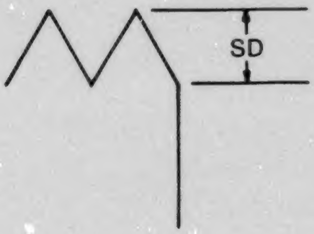
FIGURE 19



B. Determine single depth (SD) of thread (Figure 20)

(NOTE: Use the formula $SD = 0.64952 \times L$.)

FIGURE 20

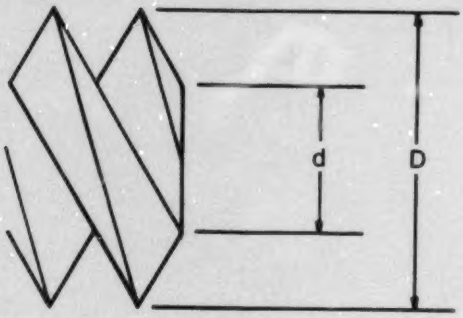


INFORMATION SHEET

C. Determine minor diameter (d) (Figure 21)

(NOTE: Use the formula d = [Major diameter] − 2[SD].)

FIGURE 21



D. Determine required depth of each pass

1. Use the guideline first pass = $\frac{1}{3}$ (SD)

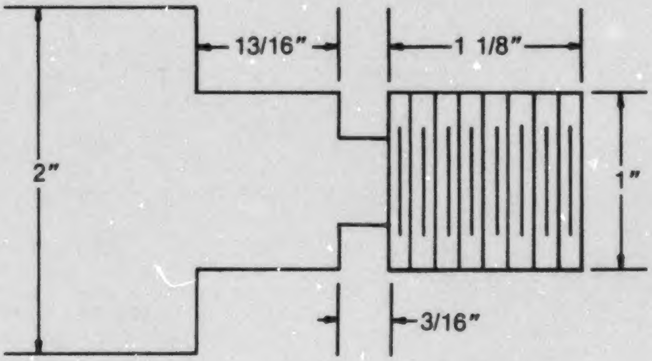
   (NOTE: Depth of cut must not exceed 0.015".)

INFORMATION SHEET

2. Decrease depth of cut for each subsequent pass until minor diameter is reached

EXAMPLE: Thread part shown with 8 threads per inch

FIGURE 22



$$L = \frac{1}{\#\ \text{threads/inch}} = \frac{1}{8}$$

$$\begin{aligned} SD &= 0.64952 \times L \\ &= 0.64952 \times {}^{1}/_{8}'' \\ &= 0.08119'' \end{aligned}$$

$$\begin{aligned} d &= D - 2(SD) \\ &= 1.0'' - 0.16238'' \\ &= 0.83762'' \end{aligned}$$

Determine depth of cuts

$$\begin{aligned} \text{First pass} &= {}^{1}/_{3}\,(SD) \\ &= {}^{1}/_{3}\,(0.08119) \\ &= 0.02706'' \end{aligned}$$

(NOTE: Remember that depth of cut should not exceed 0.015". Thus, you would use 0.015" for the first pass and decrease each subsequent pass. Note, also, that each pass wil reduce the diameter by twice the amount of the depth of cut. An example of one threading schedule decreasing each pass by 0.001" is shown below.)

INFORMATION SHEET

Pass #	Depth of cut	Resulting diameter
1	0.015"	0.970"
2	0.014"	0.942"
3	0.013"	0.916"
4	0.012"	0.892"
5	0.011"	0.870"
6	0.010"	0.850"
7	0.0062"	0.8376"
8	0.0062"	0.8376"

(NOTE: Notice that the next to last depth of cut was reduced further to obtain the required minor diameter. A second pass was then made at that same diameter to clean the thread, a procedure referred to as a *spring pass.*)

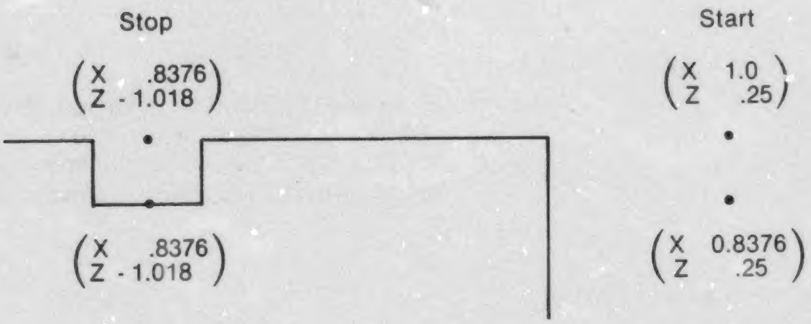
INFORMATION SHEET

E. Determine the start and stop points for each thread pass

(NOTE: This is done in the same way you normally determine coordinate points using a drawing of the part. The start point is approximately two times the amount of the lead from the part. The stop point must be far enough to ensure that the part is fully threaded.)

EXAMPLE: Using the part shown above and the depths of cuts as calculated, the start and stop points of the first and last passes would be as shown below.

FIGURE 23



XII. Factors to consider when selecting tooling required for a procedure

A. Type of operation to be performed

EXAMPLES: Turning, drilling, reaming, boring, threading

B. Material to be machined

C. Size and geometry of part

D. Finish required

E. Capabilities of tool or insert

EXAMPLES: Type and grade of tool or insert, depths of cut, tool geometry

INFORMATION SHEET

XIII. Guidelines for planning procedure

A. Review print

B. Identify all required operations

C. Sequence operations

(NOTE: It is very important to properly sequence the operations. If the procedure is not sequenced correctly then one machine application may be counterproductive to another. For example, finish boring should never be done before finish facing. Boring after the face cut will remove burrs from the corner of the part, but facing after the finish bore will leave a burr on the corner of the part.)

D. Select tools for each operation

E. Plan turret tooling setup for sequence of operations

F. Determine U and W program home points

G. Write setup sheet

H. Reevaluate procedure sequence and setup after test run and after first run

XIV. Calculating speeds and feeds

(NOTE: The program covers every step of the operation, including spindle speeds and the rates of feed for each tool on each cut. Therefore, it is essential that the programmer be able to calculate speeds and feeds.)

A. Calculate revolutions per minute (rpm)

1. Locate correct surface feet per minute (sfpm) speed on appropriate chart for operation, material, and type of cut

(NOTE: Charts may be found in a machinist's handbook or other references. A sample chart is included with Assignment Sheet #4.)

INFORMATION SHEET

2. Use formula $\text{rpm} = \dfrac{4 \times \text{sfpm}}{D}$

   (NOTE: D is the diameter being cut, either an outside or inside diameter. The number 4 is a constant.)

   EXAMPLE: To drill a 3.0" diameter in 1020 annealed low carbon steel, the sfpm is 80. The rpm would be

$$\begin{aligned} \text{rpm} &= \frac{4 \times \text{sfpm}}{D} \\ &= \frac{4 \times 80}{3.0} \\ &= \frac{320}{3.0} \\ &= 106.6 \text{ or } 107 \end{aligned}$$

B. Calculate inches per minute (ipm) feed rate

1. Calculate rpm

2. Locate correct inches per revolution (ipr) feed rate on appropriate chart for operation, material, and type of cut

3. Use formula ipm = ipr × rpm

   EXAMPLE: For the turning operation discussed in the example above, the chart shows a feed rate of 0.004". Thus,

$$\begin{aligned} \text{ipm} &= \text{ipr} \times \text{rpm} \\ &= 0.004 \times 107 \\ &= 0.428 \end{aligned}$$

C. To convert from one known rate to an unknown rate, use the appropriate formula

EXAMPLES: 1. $\text{ipr} = \dfrac{\text{ipm}}{\text{rpm}}$

2. ipm = ipr × rpm

3. $\text{rpm} = \dfrac{\text{ipm}}{\text{ipr}}$

INFORMATION SHEET

XV. Steps in writing a program

A. Review setup sheet and planning notes

(NOTE: Examples used in this section refer to the part illustrated in Section VI.)

B. Write step-by-step commands required to perform operation of first tool

(NOTE: As you begin to write a program, keep in mind the need to program each tool so that a cycle begins for each tool. For instance, if you break an insert on the cut-off tool, while it is cutting, you must stop the cycle and change the insert. To begin the cycle, you do not want to start the program over from the top, so you should build in the flexibility to begin with any tool number.)

EXAMPLE: Build in general parameters of the program in the first data block such as inch or metric system and type of feed (ipr and ipm). First block will look like: N0010 G20 G99 T0100.

C. Preset home position in block #2 for X and Z axes and set maximum spindle speed

EXAMPLE: Set calculated G50 values for X, Z, and S. Set maximum speed at 2000 rpm. Refer to tooling manual for machine parameters when setting G50 values.

D. Set spindle speed and start spindle in block #3

EXAMPLE: Reference tables give 3.50 sfpm for roughing speed. Block will be N0030 G 96 S350 M03.

E. Position for first cut in block #4

(NOTE: References of drawings and dimensions will be made. Also start the coolant and pick up the offset.)

EXAMPLE: Block should read N0040 G00 X3.100 Z.01 M08 T0101.

F. Make first cuts

(NOTE: Use feed rates determined from reference table.)

EXAMPLE: N0050 G01 X0.0 F.0150

INFORMATION SHEET

G. Rapid travel away from the part

EXAMPLE: The block would be N0060 G00 Z.1.

H. Position for next cut

(NOTE: Because G00 is a modal command, it does not have to be repeated.)

EXAMPLE: The block would be N0070 X2.6.

I. Cut to Z dimension

(NOTE: You do not need to reprogram feed unless you wish to change the feed rate.)

EXAMPLE: The block would be N0080 G01 Z−2.45.

J. Move away from part, while still in feed mode

EXAMPLE: The block would be N0090 X3.1.

K. Rapid travel to Z clearance

EXAMPLE: The block would be N0100 G00 Z.1.

L. Rapid travel to next X diameter

EXAMPLE: The block would be N0110 X2.2.

M. Repeat steps until part is roughed out

EXAMPLE OF BLOCKS:

```
N120 G01 Z-2.4
N0130 X2.6
N0140 G00 Z.1
N0150 X1.8
N0160 G01 Z-1.43
N0170 X2.12
N0180 Z-2.4
N0190 X2.2
N0200 G00 Z.1
N0210 X1.4
N0220 G01 Z-1.43
N0230 X1.8
N0240 G00 Z.1
N0250 X1.06
N0260 G01 Z-1.43
N0270 X1.4
N0280 G00 Z.1
```

N. Rapid travel back to home position and cancel offsets

EXAMPLE: The block would be N0290 X 7.75 Z 13.085 T0100.

O. End with a program stop

EXAMPLE: The block would be N0300 M0.

P. Review setup sheet

INFORMATION SHEET

Q. Write step-by-step commands required to perform operation of second tool

EXAMPLE: Build in general parameters of the program in the first data block such as inch or metric system, tool station selection and offset, and type of feed (ipr or ipm). First block will look like N0310 G20 G98 T0200.

R. Preset home position in next block for X and Z axes and set maximum spindle speed

EXAMPLE: The block would be N0320 G50 X 7.75 Z 13.085 S 2000.

S. Set spindle speed and start spindle in block #3

EXAMPLE: Reference tables state for sfpm speed for roughing we use 125, so block will be N0330 G96 S500 M04.

T. Position for first cut in next block

EXAMPLE: Block should read N0340 G00 X 1.100 Z0.0 M08 T0202.

U. Make first cut

EXAMPLE: The block would be N0350 G01 X0.0 F.006

V. Rapid travel away from the part

EXAMPLE: The block would be N0360 G00 Z.100.

W. Input the remaining blocks

```
N0370 X 1.0
N0380 G01 Z-1.437
N0390 X 1.912
N0400 X 2.062 Z-1.562
N0410 Z-2.281
N0420 G02 X 2.5 Z-2.5 1.219
N0430 G03 X 3.0 Z-2.75 K-.250
N0440 G01 Z-4.0
N0450 X 3.1
N0460 G00 Z.1
N0470 X 7.75 Z13.088 T0200
N0480 M00
N0490 G20 G98 T0300
N0500 G50 X 7.75 Z13.085 S2000
N0510 G96 S250 M03
N0520 G00 X 3.1 Z-4.125
N0530 G01 X 0 F.002
N0540 G00 X 3.100
N050 X 7.75 Z13.085 T0300
N0560 M30                                          Program End
```

INFORMATION SHEET

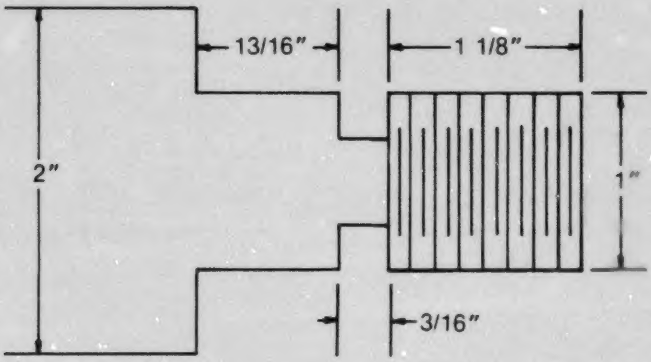
XVI. Writing a program to cut dwell

(NOTE: A dwell is a timed slot cut, often used on a part at the end of a thread to allow completion of the threaded portion.)

A. Use drawing to determine start and stop points (Figure 24)

EXAMPLE:

FIGURE 24



B. Write first three blocks of sequence

EXAMPLE: For the part above, the first three blocks might be as follows using an arbitrary tool station and G50 position:

```
N0010 G20 G99 T0700
N0020 G50 X8.0 Z10.0 S1000
N0030 G96  S300 M04.
```

C. Write block to rapid traverse tool into position for cut

(NOTE: Be sure to turn on coolant and pick up offset.)

EXAMPLE: The block would be

```
N0040 G00 X2.1 Z1.125 T0707 M08.
```

D. Write a block to feed tool to required X position

EXAMPLE: The block would be

```
N0050 G01 X.8125 F.005.
```

INFORMATION SHEET

E. Program required dwell time

EXAMPLE: The block would be
N0060 G98 G04 P1500.

(NOTE: Change to G98 [ipm] in order to convert feed into a timed operation in order to set the dwell. *P* specifies the amount of time of dwell. Because the program uses a fixed decimal point in P values, the operator or programmer does not have to load a decimal point. The machine will automatically read an imaginary decimal point three places from the right. Thus, in the example, the time for the dwell is 1.5 seconds [P1500].)

F. Write blocks to retract tool from slot and return to setup position

XVII. Writing a program for threading

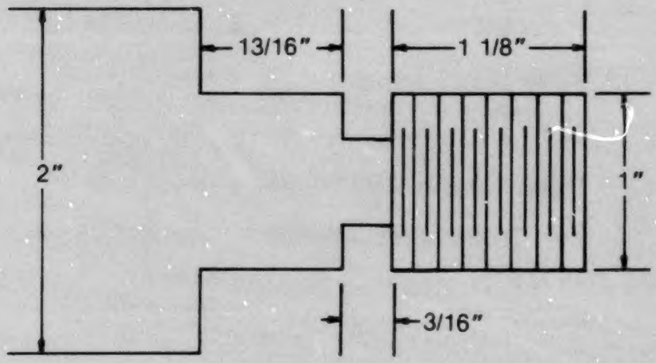
A. Threading with G32

1. Use drawing to determine start and stop points for threading (Figure 25)

(NOTE: The procedure was covered in Section XI of this information sheet.)

EXAMPLE:

FIGURE 25



INFORMATION SHEET

2. Write first three blocks of sequence

   EXAMPLES: For the part shown above with the dwell cut, the first three blocks might be as follows using an arbitrary tool station and G50 position:

   ```
   N0010 G20 G99 T0500
   N0020 G50  X8.0  Z10.0
   N0030 G79 S1000 M03.
   ```

3. Write block to rapid traverse for first tool pass

   (NOTE: Be sure to turn on coolant and pick up offset.)

   EXAMPLE: The block would be

   ```
   N0040 G00 X.97 Z.25 T0505 M08.
   ```

4. Include the threading by G32 command in the next block

   EXAMPLE: The block would be

   ```
   N0050 G32 Z-1 F1.25.
   ```

5. Write block to retract tool to clear part

   EXAMPLE: The block would be

   ```
   N0060 G00 X1.1.
   ```

6. Write block to return tool to starting Z position

   EXAMPLE: The block would be

   ```
   N0070 G00 Z.25.
   ```

7. Write blocks for remaining passes and returns to compl[illegible] thread

   (NOTE: Be sure to include spring pass to clean thread [illegible]

B. Threading with G92

1. Use drawing to determine start and stop points for threading

2. Write first three blocks of sequence

3. Write block to rapid traverse into position for first tool pass

   (NOTE: The X value with G92 threading must be clear of the diameter to be threaded.)

   EXAMPLE: This block would be

   ```
   N0040 G00 X1.1 Z.25 T0505 M08.
   ```

INFORMATION SHEET

4. Include threading by G92 canned thread command in next block

   EXAMPLE: This block would be
   N0050 G92 X.97 Z-1.0 F.125.

   (NOTE: This command will position tool for first cut. The Z axis will feed to the length of the thread, and then the X axis will automatically retract to clearance diameter and Z axis will return to starting Z position.)

5. Write X value blocks for remaining passes to complete thread

WRITE A PROGRAM
UNIT VI

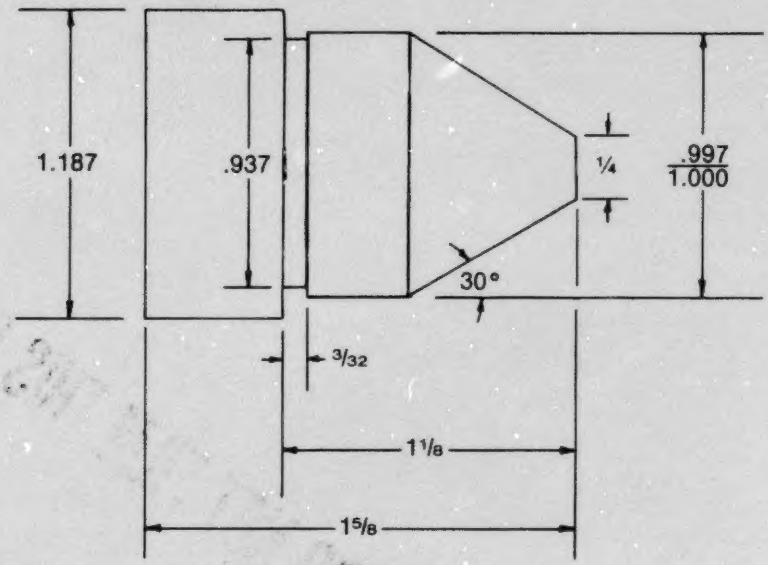
ASSIGNMENT SHEET #1 — DRAW FROM A BLUEPRINT

NAME ______________________________ SCORE ______________

CNC technicians must be able to convert drawings of a part from the blueprint. The drawing illustrates to the technician all dimensions that must be machined during the operations.

Given below are the blueprint and the necessary information for making the drawing. Draw the part using the space provided on the following page.

A. The part number is 1-36814 and the part name is STEM PLUG. The part is to be machined from 1 1/2" round, 316 stainless steel.



ASSIGNMENT SHEET #1

B. Use the space below to draw the part you plan to write a program for.

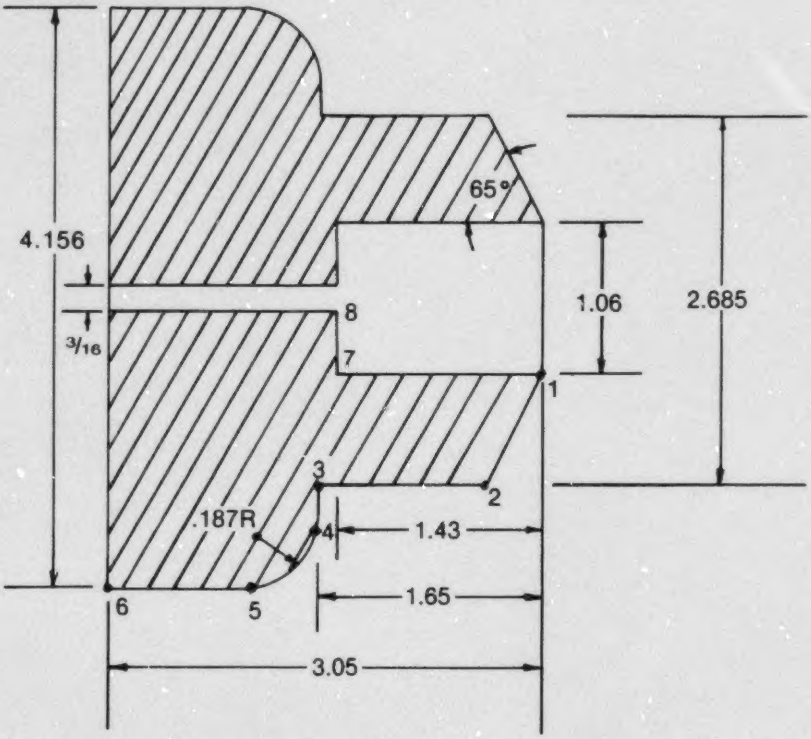
WRITE A PROGRAM
UNIT VI

ASSIGNMENT SHEET #2 — CALCULATE POINT VALUES FROM A DRAWING

NAME ______________________________ SCORE ______________

A CNC turning technician must be able to determine X and Z values when viewing a blueprint in order to develop a program for turning a part. In the drawings below, label the points indicated using the method listed.

A. Label the points using the absolute method.


4.156
3/16
65°
1.06
2.685
8
7
1
3
2
.187R
4
1.43
1.65
6
5
3.05

1. ______________________

2. ______________________

3. ______________________

4. ______________________

5. ______________________

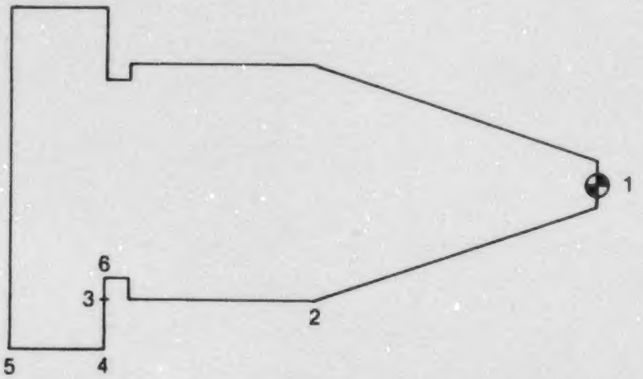
6. ______________________

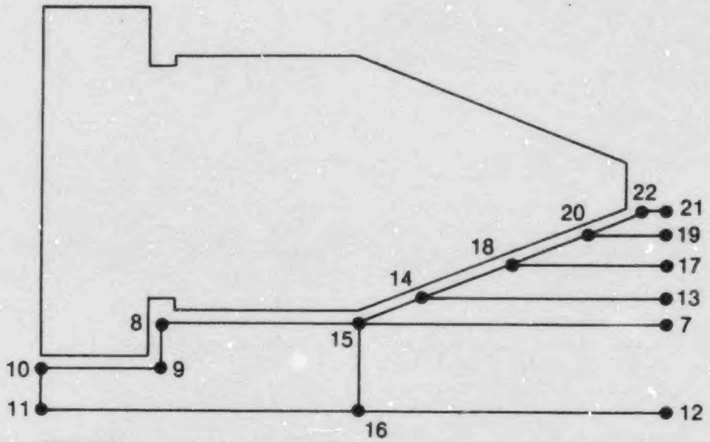
7. ______________________

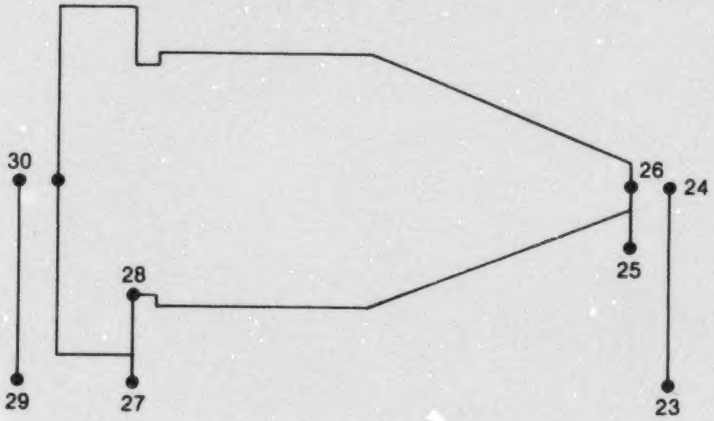
8. ______________________

ASSIGNMENT SHEET #2

B. Use the incremental method to figure the values of the points below. The drawing is of the stem plug used in Assignment Sheet #1. Use the blueprint in the previous assignment sheet and a rough cut depth of 0.100".




22
21
20
19
18
17
14
13
8
7
15
10
9
11
16
12


30
26
24
25
28
29
27
23

ASSIGNMENT SHEET #2

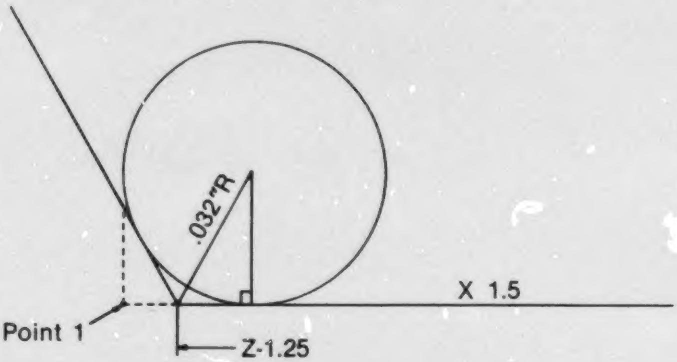
Points	X Value	Z Value
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		
21.		
22.		
23.		
24.		
25.		
26.		
27.		
28.		
29.		
30.		

ASSIGNMENT SHEET #2

C. Calculate the program X and Z values for tool radius compensation in the drawings below.

1. Point 1 — X______________ Z______________

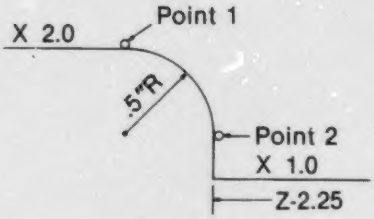
(NOTE: The tangent for 30° is 0.577.)


.032"R
X 1.5
Point 1
Z-1.25

2. a. Point 1 — X______________ Z______________

b. Point 2 — X______________ Z______________

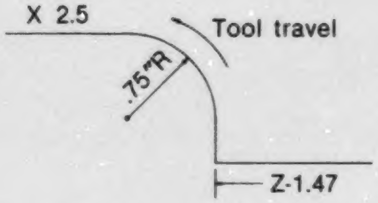
(NOTE: Assume tool radius to be 0.032".)


X 2.0
Point 1
.5"R
Point 2
X 1.0
Z-2.25

ASSIGNMENT SHEET #2

D. Calculate I and K values for the part below.

I________________ K________________



E. Calculate point values for the part you are writing a program for. Use your drawings in Assignment Sheet #1 and the blank page of Assignment Sheet #1 for drawings and calculations.

WRITE A PROGRAM
UNIT VI

ASSIGNMENT SHEET #3 — PLAN PROCEDURE

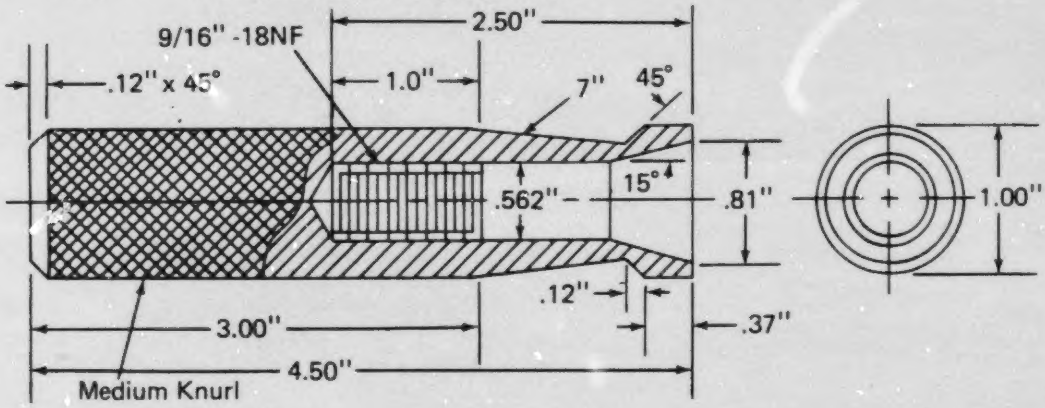
NAME ____ SCORE ________________

Before a program can be written, the machining procedure must first be planned. The operations and tools must be determined and properly sequenced. Once this has been done, the specific codes can be identified and set up as program blocks.

Practice planning procedures by completing the exercises below.

A. Study the blueprint below and answer the questions on the following page.

Part A Material: 2024T4 Aluminum


2.50"
9/16" -18NF
.12" x 45°
1.0"
7"
45°
15°
.562"
.81"
1.00"
.12"
.37"
3.00"
4.50"
Medium Knurl

ASSIGNMENT SHEET #3

B. Read the operations below that may be required to make this file handle. Check those operations that can be programmed for the CNC lathe.

_____ 1. Turning O.D.

_____ 2. Cutting dwell

_____ 3. Recessing

_____ 4. Boring I.D.

_____ 5. Cutting internal threads

_____ 6. Center drilling

_____ 7. Drilling 9/16" hole

_____ 8. Drilling 5/16" hole

_____ 9. Slotting

_____ 10. Turning 15° I.D. taper

_____ 11. Knurling

_____ 12. Cutoff

C. List the operations in the sequence they should be performed on the lathe. Indicate rough and finish cuts.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____

D. List the tools and chucking devices required for the lathe operations.

1. _____
2. _____
3. _____
4. _____
5. _____

ASSIGNMENT SHEET #3

6. ____________________

7. ____________________

8. ____________________

9. ____________________

10. ____________________

E. How many setups are required? ____________________

F. Indicate below how the turret would be arranged for each setup.

Position	Setup #1	Setup #2	Setup #3
1			
2			
3			
4			
5			
6			
7			
8			

G. Plan the tooling and operation required for your program on separate paper.

WRITE A PROGRAM
UNIT VI

ASSIGNMENT SHEET #4 — CALCULATE SPEEDS AND FEEDS

NAME ______________________________ SCORE ____________

A CNC turning technician must become proficient in calculating speeds and feeds in order to monitor production and to hold part consistency.

A. Use the formulas given in the information sheet to solve the following problems.

1. In order to turn a part that is 4" O.D. at 400 sfpm, what is the rpm required?

   rpm = ____________

2. If part is turning 268 rpm on a 2" I.D., what is sfpm?

   sfpm = ____________

3. At 300 rpm and .010 ipr, what is ipm?

   ipm = ____________

ASSIGNMENT SHEET #4

4. If ipm is 6.5 and rpm is 800, what is ipr?

ipr = ______________

5. If ipm is 7.3 and ipr is .006, what is rpm?

rpm = ____________

B. Use the chart on the following page to determine speeds and feeds in the situations below.

1. Turn the outside diameter of a 4" hard cast-iron pipe valve to 3.875", using carbide (throw-away) cutting tools.

a. Rough turn = ____________________ rpm

b. Finish turn = ____________________ rpm

c. Rough turn = ____________________ ipr

d. Finish turn = ____________________ ipr

e. Total amount of material to be removed = ________________________

2. Turn a 1 1/2" aluminum bar down to 1 1/8" diameter using high-speed steel cutting tools.

a. Rough turn = ____________________ rpm

b. Finish turn = ____________________ rpm

c. Rough turn = ____________________ ipr

d. Finish turn = ____________________ ipr

e. Total amount of material to be removed = ________________________

TURNING							
			HIGH-SPEED STEEL TOOL		CARBIDE TOOL		
					Speed SFPM (CS)		
MATERIAL	Finish*	Depth of Cut (Inches)	Speed sfpm (CS)	Feed ipr	Brazed	Throw-away	Feed ipr
Aluminium Alloys	R	0.150	600	0.015	1100	1500	0.020
--Wrought	F	0.025	800	0.007	1400	1800	0.010
Brass	R	0.150	400	0.015	800	925	0.020
330-340-353	F	0.025	480	0.007	960	1100	0.007
Cast Iron	R	0.150	145	0.015	500	550	0.020
Soft	F	0.025	185	0.007	650	725	0.010
Cast Iron	R	0.150	80	0.015	300	340	0.015
Hard	F	0.025	120	0.007	360	410	0.007
Carbon Steel (Lo)	R	0.150	120	0.015	400	485	0.020
1010-1020	F	0.025	160	0.007	475	625	0.007
Carbon Steel (Med)	R	0.150	75	0.015	300	375	0.020
1030-1055	F	0.025	105	0.007	385	475	0.007
Carbon Steel (Hi)	R	0.150	65	0.015	275	345	0.015
1060-1095	F	0.025	85	0.007	360	440	0.007
Alloy Steel (Med C)	R	0.150	90	0.015	300	400	0.020
4130-4140	F	0.025	120	0.007	400	500	0.007
Tool Steel (HS)	R	0.150	60	0.015	250	290	0.015
M-3, M-4, M-7	F	0.025	65	0.007	275	320	0.007
Stainless Steel	R	0.150	105	0.015	425	475	0.015
300 Series	F	0.025	125	0.007	475	520	0.007
Stainless Steel	R	0.150	150	0.015	475	525	0.015
400 Series	F	0.025	170	0.007	525	590	0.007

*"R" designates rough cut depths to cut; "F" designates finish cut depths of cut.

(NOTE: Although these cutting speeds can be used to calculate lathe spindle speeds, such speeds are approximate values and need to be adjusted for type and condition of machine, exact dimensions of operation, type of material being machined, and operator skill and experience.)

WRITE A PROGRAM
UNIT VI

ASSIGNMENT SHEET #5 — WRITE A SETUP SHEET

NAME ______________________________ SCORE ______________

CNC technicians need certain information to properly set up a job to machine a part. The setup sheet provides the needed information.

A. Use the space below and the form on the following page to write a setup sheet for the stem plug in Assignment Sheets #1 and #2.

Set-Up Sheet

Part Name ____________ Operation # ____________

Part No. ____________ Date ____________

Tape No. ____________ Prog. by ____________

First Run ____________ Revised ____________

Home Position U ____________ W ____________

Chucking Details ☐ Hard ☐ Soft

Max. Gripping Length ____________

Jaw No. ____________

Comments to Oper. ____________

____

____

Tool	Offset	Tool Ident. No.	Tool Desc.	Insert	Grade	Radius
1						
2						
3						
4						
5						
6						
7						
8						

ASSIGNMENT SHEET #5

B. Use the space below and the setup sheet on the next page to plan the setup for the part you are writing a program for.

Set-Up Sheet

Part Name__________ Operation # __________
Part No.__________ Date __________
Tape No.__________ Prog. by__________
First Run__________ Revised__________
Home Position U__________ W__________
Chucking Details ☐ Hard ☐ Soft
Max. Gripping Length__________
Jaw No. __________
Comments to Oper. __________

Tool	Offset	Tool Ident. No.	Tool Desc.	Insert	Grade	Radius
1						
2						
3						
4						
5						
6						
7						
8						

WRITE A PROGRAM
UNIT VI

ASSIGNMENT SHEET #6 — WRITE A PROGRAM

NAME ______________________________ SCORE ______________

CNC technicians rely on programs for information and illustrations needed to produce a part within blueprint specifications and tolerances.

A. Use information sheet and Assignment Sheets #1 through #5 to write a program for the stem plug. Use the space below and the back of this sheet.

ASSIGNMENT SHEET #6

B. Use the space below and the next page to write a program for the part you have chosen.

WRITE A PROGRAM
UNIT VI

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1 — Evaluated to the satisfaction of the instructor

Assignment Sheet #2

A.

1.	X 1.06	Z 0	5.	X 4.156	Z - 1.837
2.	X 2.685	Z - .3788	6.	X 4.156	Z - 3.050
3.	X 2.685	Z - 1.650	7.	X 1.060	Z - 1.430
4.	X 3.782	Z - 1.650	8.	X 1.875	Z - 1.430

B.

	X	Y
1	.250	0
2	.9985	-.6486
3	.9985	-1.125
4	1.187	-1.125
5	1.187	-1.625
6	.937	-1.125
7	1.050	.100
8	1.050	-1.125
9	1.210	-1.125
10	1.210	-1.625
11	1.350	-1.625
12	1.350	.100
13	.850	.100
14	.850	-.500

ANSWERS TO ASSIGNMENT SHEETS

	X	Y
15	1.050	−.6732
16	1.350	−.6732
17	.650	.1000
18	.650	−.327
19	.450	.1000
20	.450	−.173
21	.250	.1000
22	.250	.019
23	1.350	.010
24	.000	.010
25	.350	.000
26	.000	.000
27	1.350	−1.125
28	.937	−1.125
29	1.350	−1.750
30	.000	−1.750

C. 1. X 1.5 Z−2.2636

2. a. X 2.0 Z−2.782

b. X 1.468 Z−2.25

D. I 0 K−.75

E. Evaluated to the satisfaction of the instructor

Assignment Sheet #3 — Evaluated to the satisfaction of the instructor

(NOTE: Answers will vary depending on the type of lathe used.)

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #4

A. 1. 382 rpm

2. 140 sfpm

3. 3 ipm

4. 0.008 ipr

5. 1216 rpm

B. 1. a. 1600 rpm

b. 2844 rpm

c. 0.015 ipr

d. 0.007 ipr

e. 0.375"

2. a. 340 rpm

b. 423 rpm

c. 0.015 ipr

d. 0.007 ipr

e. 0.125"

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #5

A.

TOOL	OFFSET	TOOL IDENT. NO.	TOOL DESC.	INSERT	GRADE	RADIUS
1	1	MCLNR 16-4	ROUGH O.D.	CNMG432	C-6	1/32
2	2	MCLNR 16-4	FINISH O.D.	CNMG432	C-7	1/32
3	3	MVTNR 16-3	O.D. GROOVE	TNMG33	C-7	3/32" wd
4	4		CUT-OFF			1/8" wd
5						
6						
7						
8						

B. Evaluated to the satisfaction of the instructor

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #6

Part A

```
%
N0010 G20 G99 T0100
N0020 G50 X7.75 Z18.585 S2000
N0030 G96 S400 M03
N0040 G00 X1.35 Z.01 T0101 M08
N00 G01 X0 F.012
N0060 G00 Z.1
N0070 X1.05
N0080 G01 Z-1.125
N0090 X1.210
N0100 Z-1.625
N0110 X1.35
N0120 G00 Z.1
N0130 X.85
N0140 G01 Z-.5
N0150 X1.05 Z-.6732
N0160 X1.35
N0170 G00 Z.1
N0180 X.650
N0190 G01 Z-.327
N0200 X.85 Z-.5
N0210 X1.05
```

ANSWERS TO ASSIGNMENT SHEETS

```
X0220 G00 Z.1

N0230 X.45

N0240 G01 Z-.173

N0250 X.650 Z-.327

N0260 G00 X.85

N0270 Z.1

N0280 X.25

N0290 G01 Z.019

N0300 X.45 Z-.173

N0310 X.65

N0320 G00 Z.1

N0330 X[illegible]75 Z18.585 T0100 M09

N0340 M01

N0350 G20 G99 T0200

N0360 G50 X7.75 Z18.585 S2000

N0370 G96 S550 M03

N0380 G00 X.35 Z.0 T0202 M08

N0390 G01 X0 F.006

N0400 G00 Z.1

N0410 X.25

N0420 G01 Z0

N0430 X.9285 Z-.6486

N0440 Z-1.125

N0450 X1.187

N0460 Z-1.625
```

ANSWERS TO ASSIGNMENT SHEETS

```
N0470 X1.35
N0480 G00 Z.1
N0490 X7.75 Z18.585 T0200 M09
N0500 M01
N0510 G20 G99 T0300
N0520 G50 X7.75 Z18.585 S1000
N0530 G96 S3000 M03
N0540 G00 X1.35 Z-1.125 T0303 M08
N0550 G01 X.937 F.004
N0560 X1.35
N0570 G00 X7.75 Z18.585 T0300 M09
N0580 M01
N0590 G20 G99 T0400
N0600 G50 X7.75 Z18.585 S2000
N0610 G96 S2000 M03
N0620 G00 X1.35 Z-1.75 T0404 M08
N0630 G01 X0 F.003
N0640 G00 X1.35
N0650 G00 X7.75 Z-18.585 T0400 M09
N0660 M30
%
```

Part B - Evaluated to the satisfaction of the instructor

WRITING A PROGRAM
UNIT VI

TEST

NAME ______________________________ SCORE ______________

1. Match terms associated with writing a program to their correct definitions. Write the correct numbers in the blanks.

_____a. Sheet showing all codes and instructions for a program

_____b. Word address for numbering data blocks

_____c. Group of instructions that causes specific machine actions

_____d. Command for doing a repetitive series of fixed motions

_____e. Point of origin for program; X0, Z0

_____f. Handwritten program sheet

_____g. Predetermined series of motions for a tool path

_____h. Information to cause motion or to convey information to control

1. Program
2. Manuscript
3. Readout
4. Datum point
5. Canned cycle
6. Multiple repetitive cycle
7. Data block
8. Sequence number

2. State purpose of the program.

____

____

____

TEST

3. Match program letters to their basic functions. Write the correct numbers in the blanks.

______a. Specifies incremental positioning of Z-axis

______b. Denotes the sequence numbers for all data blocks

______c. Indicates radius length of arc

______d. Denotes arc center offset for X-axis

______e. Indicates tool and offset selection

______f. Specifies Z-axis position

______g. Indicates miscellaneous functions

______h. Specifies incremental positioning of X-axis

______i. Sets the mode of operation for preparatory functions

______j. Denotes arc center offset for Z-axis

______k. Indicates spindle speed selection

______l. Indicates feed rate selection

______m. Specifies X-axis position

1. N
2. G
3. X
4. Z
5. U
6. W
7. I
8. K
9. F
10. R
11. S
12. T
13. M

4. Match G codes to their modes of operation. Write the correct numbers in the blanks.

Universal control codes

______a. Face grooving cycle

______b. Dwell

______c. Multiple repetitive roughing cycle for contouring cuts

______d. Cutter radius compensation off

______e. IPR

______f. Linear interpolation

______g. IPM

______h. Automatic zero return (automatic home)

1. G00
2. G01
3. G02
4. G03
5. G04
6. G20
7. G21
8. G27

TEST

_____i. Preset position register

_____j. Canned cycle for threading

_____k. Counterclockwise circular interpolation

_____l. Metric mode

_____m. Multiple repetitive roughing cycle for facing cuts

_____n. Canned cycle for facing cuts

_____o. Inch mode

_____p. Canned cycle for longitudinal turning

_____q. Multiple repetitive roughing cycle for longitudinal turning

_____r. Cutter radius compensation left

_____s. Cutter radius compensation right

_____t. RPM designation for spindle speed

_____u. Clockwise circular interpolation

_____v. O. D. grooving cycle

_____w. Threading, single pass

_____x. Finish cycle for multiple repetitive cycles

_____y. Rapid traverse

_____z. SFM designation for spindle speed

_____aa. Zero return check (home check)

_____bb. Multiple repetitive threading cycle

9. G28
10. G32
11. G40
12. G41
13. G42
14. G50
15. G70
16. G71
17. G72
18. G73
19. G74
20. G75
21. G76
22. G90
23. G92
24. G94
25. G96
26. G97
27. G98
28. G99

TEST

American control codes

______a. Absolute

______b. IPM

______c. Threading

______d. Metric mode

______e. IPR

______f. Inch mode

______g. Home preset

______h. Incremental

1. G33
2. G70
3. G71
4. G90
5. G91
6. G92
7. G94
8. G95

5. Match M codes to their functions. Write the correct numbers in the blanks.

______a. Spindle on forward (cw)

______b. Program end—rewind stop

______c. Subroutine call

______d. Optional stop

______e. Spindle off

______f. Subroutine return

______g. Spindle on reverse (ccw)

______h. Coolant off

______i. Program stop

______j. Coolant on

______k. I.D. chucking

______l. Program end

______m. O.D. chucking

1. M00
2. M01
3. M02
4. M03
5. M04
6. M05
7. M08
8. M09
9. M30
10. M65
11. M66
12. M98
13. M99

TEST

6. Select from a list steps to draw part from blueprint for program planning. Place an "X" before each correct answer.

_____a. Study setup sheet

_____b. Study blueprint

_____c. Select view that shows most significant dimensions for operation to be done

_____d. Draw a profile of the part with the chucked end to the left

_____e. Label datum point

_____f. Place a dot at each point where lines intersect on one half of the drawing

_____g. Repeat procedure to place a dot on each point where lines intersect on the other half of the drawing

_____h. Determine the X and Z values for each point

_____i. Label the points with their X and Z values

_____j. Determine rough and finish depths of cuts

_____k. Make another drawing of the part profile or use other half of first drawing

_____l. Add lines to the drawing to represent each rough cut; place a dot at each end of each rough cut line

_____m. Calculate the X and Z values for the starting point and end of each rough cut

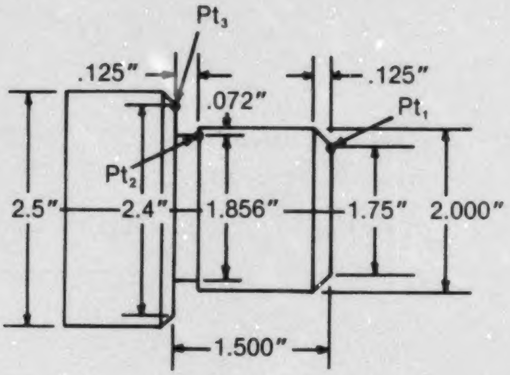
_____n. Label the points midway between each rough cut start and stop

_____o. Label the X and Z values of the rough cuts

_____p. Repeat the procedure to produce labeled drawings for other required machining operations, such as drilling holes, changing the end to be chucked, etc

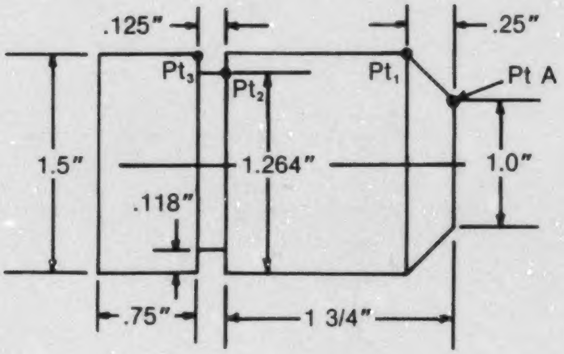
TEST

7. Calculate the X and Z values of the points in the drawing below using the absolute method.


Pt₃
.125"
.072"
.125"
Pt₁
Pt₂
2.5"
2.4"
1.856"
1.75"
2.000"
1.500"

	X	Z
a. Point 1		
b. Point 2		
c. Point 3		

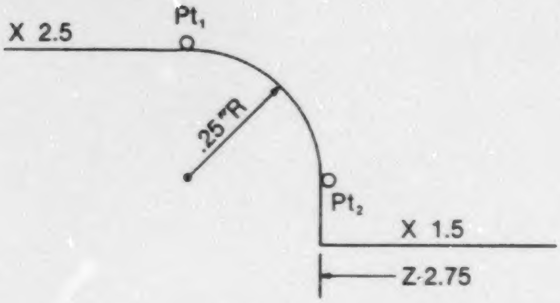
8. Use the incremental method to calculate U and W distances to travel to the points in the drawing below. Use point A as the starting point.


.125"
.25"
Pt₃
Pt₂
Pt₁
Pt A
1.5"
1.264"
1.0"
.118"
.75"
1 3/4"

	U	W
a. Point 1		
b. Point 2		
c. Point 3		

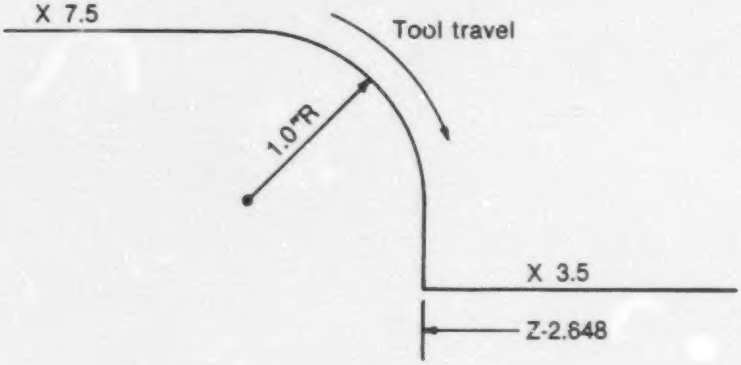
TEST

9. Calculate the X and Z values for the points in the drawing below using tool radius compensation. Use a tool radius of 0.0032".


X 2.5
Pt₁
.25"R
Pt₂
X 1.5
Z-2.75

	X	Z
a. Point 1	__________	__________
b. Point 2	__________	__________

10. Calculate the I and K values for the radius in the drawing below.


X 7.5
Tool travel
1.0"R
X 3.5
Z-2.648

	I	K
a.	__________	__________

TEST

11. Select from a list steps to determine threading passes. Write an "X" in the blank before each correct answer.

_____a. Study work order

_____b. Determine lead (L) of thread

_____c. Determine single depth (SD) of thread

_____d. Use scaie to measure major diameter on print

_____e. Determine minor diameter

_____f. Determine spfm for threading

_____g. Determine required depth of each pass

_____h. Use guideline first pass = ½ SD

_____i. Decrease depth of cut for each subsequent pass until minor diameter is reached

_____j. Determine the start and stop points for each thread pass

12. Select from a list factors to consider when selecting tooling required for a procedure. Write an "X" in the blank before each correct answer.

_____a. Type of operation to be performed

_____b. Material to be machined

_____c. Coolant to be used

_____d. Size and geometry of part

_____e. Finish required

_____f. Types of toolholders at work station

_____g. Capabilities of tool or insert

13. Select from a list guidelines for planning procedure. Write an "X" in the blank before each correct answer.

_____a. Review print

_____b. Review setup sheet

_____c. Identify all required operations

TEST

_____d. Arrange operations so that straight surfaces are finished first to give good reference points to rough out curved surfaces

_____e. Sequence operations

_____f. Select tools for each operation

_____g. Plan turret tooling setup for sequence of operations

_____h. Repeat procedures for additional setups

_____i. Reevaluate procedure sequence and setup after test run and after first run

14. Calculate speeds and feeds for the situations described below.

    a. If the sfpm listed for turning a diameter in SAE 1040 is 400, what rpm is required to turn a 4" diameter?

    rpm = ____________

    b. If the ipr for boring in SAE 1030 is 0.005" and the sfpm is 200, what ipm is required for a 2.5" I. D.?

    ipm = ____________

15. Arrange in order steps in writing a program. Place a "1" before the first step, a "2" before the second step, and so on.

First Tools

_____a. Make first cuts

_____b. Rapid travel to Z clearance

TEST

______c. Write step-by-step commands required to perform operation of first tool

______d. Repeat steps until part is roughed out

______e. Position for next cut

______f. Preset home position in block #2 for X and Z axes and set maximum spindle speed

______g. Set spindle speed and start spindle in block #3

______h. Review setup sheet and planning notes

______i. Move away from part, while still in feed mode

______j. End with an optional stop

______k. Rapid travel away from the part

______l. Rapid travel to next X diameter

______m. Rapid travel back to home position and cancel offsets

______n. Cut to Z dimension

______o. Position for first cut in block #4

Remaining Tools

______a. Write step-by-step commands required to perform operation of second tool

______b. Preset home position in next block for X and Z axes and set maximum spindle speed

______c. Review setup sheet

______d. Set spindle speed and start spindle in block #3

______e. Input the remaining codes

______f. Position for first cut in next block

______g. Rapid travel away from the part

______h. Make first cut

TEST

16. Select from a list steps in writing a program to cut dwell. Write an "X" in the blank before each correct answer.

______a. Use setup sheet to determine start and stop points

______b. Use drawing to determine start and stop points

______c. Write first three blocks of sequence

______d. Write block to rapid traverse tool into position for cut

______e. Write block to feed tool to required X position

______f. Write block to feed tool to required W point

______g. Program required dwell time

______h. Write blocks to retract tool from slot and return to setup position

17. Distinguish between steps in writing a program for threading. Write a "32" beside each step used in threading with a G32 code, a "92" beside each step used in threading with a G92 code, and a "B" beside each step used in both.

______a. Use drawing to determine start and stop points for threading

______b. Write first three blocks of sequence

______c. Write block to rapid traverse for first tool pass

______d. Include threading by G32 command in the next block

______e. Include threading by G92 command in the next block

______f. Write block to retract tool to clear part

______g. Write block to return tool to starting Z position

______h. Write blocks for remaining passes and returns to complete thread

______i. Write X value blocks for remaining passes to complete thread

(NOTE: Test questions 18-23 list the assignment sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

18. Draw part from a blueprint.

19. Calculate point values from a drawing.

20. Plan procedure.

TEST

21. Calculate speeds and feeds.
22. Complete a setup sheet.
23. Write a program.

WRITE A PROGRAM
UNIT VI

ANSWERS TO TEST

1\.
a. 3
b. 8
c. 1
d. 6
e. 4
f. 2
g. 5
h. 7

2. To create a finished part machined to blueprint specifications from a piece of unfinished material.

3\.
a. 6
b. 1
c. 10
d. 7
e. 12
f. 4
g. 13
h. 5
i. 2
j. 8
k. 11
l. 9
m. 3

4. Universal control codes

a. 20
b. 5
c. 18
d. 11
e. 28
f. 2
g. 27
h. 9
i. 14
j. 23
k. 4
l. 7
m. 17
n. 24
o. 6
p. 22
q. 16
r. 12
s. 13
t. 26
u. 3
v. 19
w. 10
x. 15
y. 1
z. 25
aa. 8
bb. 21

ANSWERS TO TEST

American control codes

a. 4 e. 8
b. 7 f. 2
c. 1 g. 6
d. 3 h. 5

5. a. 4 h. 8
b. 9 i. 1
c. 12 j. 7
d. 2 k. 11
e. 6 l. 3
f. 13 m. 10
g. 5

6. b, c, d, e, f, h, i, j, k, l, m, o, p

7. a. $X = 1.75$ b. $X = 1.856$ c. $X = 2.4$
$Z = 0$ $Z = -1.375$ $Z = -1.5$

8. a. $U = .5$ b. $U = .264$ c. $U = .5$
$W = -.25$ $W = -1.75$ $W = -1.875$

9. a. $X = 2.5$ b. $X = 2.218$
$Z = -3.032$ $Z = -2.75$

10. $I = 1.0$ $K = -1.0$

11. b, c, e, g, i, j

ANSWERS TO TEST

12. a, b, d, e, g

13. a, c, e, f, g, h, i

14. a. 400

    b. 1.6

15. First Tools

    a. 6
    b. 11
    c. 2
    d. 13
    e. 8
    f. 3
    g. 4
    h. 1
    i. 10
    j. 15
    k. 7
    l. 12
    m. 14
    n. 9
    o. 5

    Remaining Tools

    a. 2
    b. 3
    c. 1
    d. 4
    e. 8
    f. 5
    g. 7
    h. 6

16. b, c, d, e, g, h

17. a. B
    b. B
    c. B
    d. 32
    e. 92
    f. 32
    g. 32
    h. 32
    i. 92

18. Evaluated to the satisfaction of the instructor

ANSWERS TO TEST

19. Evaluated to the satisfaction of the instructor

20. Evaluated to the satisfaction of the instructor

21. Evaluated to the satisfaction of the instructor

22. Evaluated to the satisfaction of the instructor

23. Evaluated to the satisfaction of the instructor

CNC TURNING TECHNICIAN

GLOSSARY OF CODES AND ABBREVIATIONS

ALM — Alarm; used to indicate alarm condition on CRT status display

B.C. — Bolt center; blueprint abbreviation used to designate bolt holes by true position

CAD — Computer assisted design

CAM — Computer assisted manufacturing

CAN — Cancel; marking of key on keypad

CCW — Counterclockwise

C.I. — Cast iron

CNC — Computer numerical control or computerized numerical control

CRT — Cathode ray tube; screen used to display control unit status

CS — Cutting speed

CSS — Constant surface speed

CW — Clockwise

d — Diameter; specifically the minor diameter of a threaded part

D — Diameter; specifically the major diameter of a threaded part

DNC — Direct numerical control; use of a computer outside the machining system to control machine operations

D_P — Print or program diameter; used in formulas to calculate offsets

DTE — Dithioerythritol; an additive in machine lubricants

D_W — Workpiece diameter; used in formulas to calculate offsets

E — Letter address to select feed rate for threading

EOB — End of block; marking of key on keypad

E-stop — Emergency stop; refers to both the process of making an emergency stop and to the button used to make an emergency stop

GLOSSARY OF CODES AND ABBREVIATIONS

F — Letter address for feed rate selection

G — Letter address for preparatory functions

G00 — Rapid traverse

G01 — Linear interpolation

G02 — Clockwise circular interpolation

G03 — Counterclockwise circular interpolation

G04 — Dwell

G20 — Inch mode

G21 — Metric mode

G27 — Zero return check (Home check)

G28 — Automatic zero return (Automatic home)

G32 — Threading, single pass

G33 — Threading, American control code

G40 — Cutter radius compensation off

G41 — Cutter radius compensation left

G42 — Cutter radius compensation right

G50 — Preset position register

G70 — Finish cycle for multiple repetitive cycles (G71, G72, G73)

G70 — Inch mode, American control code

G71 — Multiple repetitive roughing cycle for longitudinal turning

G71 — Metric mode, American control code

G72 — Multiple repetitive roughing cycle for facing cuts

G73 — Multiple repetitive roughing cycle for contouring cuts

G74 — O.D. grooving cycle

GLOSSARY OF CODES AND ABBREVIATIONS

G75 — Face grooving cycle

G76 — Multiple repetitive threading cycle

G90 — Canned cycle for longitudinal turning (single pass)

G90 — Absolute mode, American control code

G92 — Canned cycle for threading (single pass)

G92 — Home preset, American control code

G94 — Canned cycle for facing cuts (single pass)

G94 — IPM, American control code

G95 — IPR, American control code

G96 — SFM designation for spindle speed

G97 — RPM designation for spindle speed

G98 — IPM

G99 — IPR

I — Denotes arc center offset for X axis

I.D. — Inside diameter

IPM (ipm) — Inches per minute

IPR (ipr) — Inches per revolution

K — Denotes arc center offset for Z center

L — Lead of a thread

L_P — Print or program length; used in formulas to calculate offsets

L_W — Workpiece length; used in formulas to calculate offsets

M — Letter address for miscellaneous functions

M00 — Program stop

GLOSSARY OF CODES AND ABBREVIATIONS

M01 — Optional stop
M02 — Program end
M03 — Spindle on forward (CW)
M04 — Spindle on reverse (CCW)
M05 — Spindle off
M08 — Coolant on
M09 — Coolant off
M30 — Program end; rewind stop
M65 — O.D. chucking
M66 — I.D. chucking
M98 — Subroutine call
M99 — Subroutine return
MDI — Manual data input
mm — Millimeter

N — Letter address for sequence numbers in program data blocks
NC — Numerical control
No. — Number

O — Letter address for program number
O.D. — Outside diameter
OPER — Operate; operation; operator
ORR/ALM — Operate/Alarm; marking of key on keypad

POS — Position; marking of key on keypad
PRGRM — Program; marking of key on keypad
PSI (psi) — Per square inch
Pt — Point; used on prints and diagrams to label points

GLOSSARY OF CODES AND ABBREVIATIONS

R — Letter address for radius length of an arc

R_p — Part radius; used in formulas to calculate tool nose compensation

RPM (rpm) — Revolutions per minute

R_{PR} — Program radius; used in formulas to calculate tool nose compensation

R_t — Tool radius; used in formulas to calculate tool nose compensation

S — Letter address for spindle speed selection

S.A.E. — Society of American Engineers; designation for standards set by the society

SD — Single depth; used to indicate dimensions of cuts or threads

SFM (sfpm) — Surface feet per minute

SRCH — Search; status display abbreviation for sequence search

SSO — Spindle speed override

STD — Standard

T — Letter address for tool and offset selection

T.I.R. — Total indicator reading

Tp — Tape; used to designate tape numbers

U — Incremental designation for distances along X axis

W — Incremental designation for distances along Z axis

X — Designation for Cartesian coordinate axis

X0 — Offset for X axis dimension

Y — Designation for Cartesian coordinate axis

Z — Designation for Cartesian coordinate axis

Z0 — Offset for Z axis dimension